HOME-BASED TRIP GENERATION MODELLING FOR DHAKA CITY

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Thesis Acceptance Form

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THESIS

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ABSTRACT

Trip generation modelling is a fundamental and vital step in the conventional transportation planning process. It serves as a basis on which to plan, design and evaluate transportation system. Trip generation stage in transportation planning is intended to prepare forecasts of travel demand by a geographical unit. Travel demand is used here in the restrictive sense of trip-making frequency. This is the stage of travel forecasting process where the traditional linkage between land-use and travel is introduced.

This research describes the multiple linear regression model for the prediction of home-based trips per household per day ad the trip making behaviour and travel characteristics of Dhaka City. This study revealed that in Dhaka City about 93.0 percent of all trips were home-based and the rest i.e. 7.0 percent trips were non-home-based. Average number of home-based trips per household per day (trip rate) was found to be 9.43 ranging from no trip to 28 trips per day.

Household monthly income is the prime factor responsible for shaping the travel pattern. Trip rate increases with increasing family income. Trip rate of the three income group (low, middle and upper) were 7.74, 9.94 and 13.68 respectively.

Among the different modes of travel available in the City, walking and rickshaw were the major modes of travel, they constituted 36.0 and 25.0 percent of all trips respectively.

Several variables were responsible in shapping travel behaviour of Dhaka City and determining its characteristics such as household income, family size, location of residence, vehicle ownership, trip purposes, mode of travel, trip length, journey time, cost of journey etc.

The calibrated model can be used to predict future trips generated by a geographical unit -- by assuming that regression coefficients established today will hold good for any future date. This study offered a beginning framework for continuing trip generation analysis and a basic ingredient for the transportation planning process of Dhaka City.

Regression analysis was performed on the data obtained from the field survey in order to find out home-based trip generation model for Dhaka City. Independent variables for this model were selected after satisfying the selection criteria (measure of correlation and measure of association, investigation of multicollinearity). Proper testing and examination of the regression model was made before its acceptance as a forecasting tool.

Title of the Thesis : **Home-based Trip Generation Modelling for Dhaka City**

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CHAPTER I

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Transportation is not usually demanded in its own right. Few people travel simply to enjoy the journey. Trips are normally made to take advantages of opportunities that are available at particular destinations: they may be social, recreational, educational or commercial. In other words, the demand for transport is a derived one. With the exception of recreational trips, travel is not required for its own sake. It is rather a means of accomplishing some other purposes.

People travel not for travelling's sake but to get to their places of interest for some other activities such as working, shopping etc. Viewed from this point, travel is basically an undesirable activity. But it reduces the spatial disadvantages of separation by improving the potential for communication between landuse activities.

The dynamics of landuses and transport interaction is very complex and it is not always possible to establish cause and effect relationships between them. For example, improvements in transport infrastructure obviously have a profound impact on landuse activities and land values. But the converse is also true -- major changes that may occur in land uses, either by altering the size and the distribution of the residential population or shifting industrial locations, etc., tend to change the pattern of transport demand.

The primary objective of transportation planning process must, therefore, be to ensure that there should be an efficient balance between landuse activities and the potential for communication between such activities (Fleet, 1968). The medium of interaction between land-use activities and transport facilities is traffic and the objective of a transport study is, quite simply, to predict the future traffic levels and to plan facilities to accommodate this traffic.

It is particularly important to plan well and provide the right network since the investment in transport infrastructure projects is often extremely long lived. To this end, it would be ideal to capture the dynamics of landuse and transport interaction in a single analytical model but such a model does not exist.

Transport studies attempt to describe and predict the travel demand accurately using a series of linked sub-models . These sub-models simulate the decision-making process in which an individual traveler might be expected to use when considering in making a trip. Those studies were characterized by systematized process, when carried through, serves as a basis on which to plan, design and evaluate transportation systems. This process is generally considered to be comprised of the following key technical phases: population and economic studies, location of landuses, trip generation, trip distribution, modal split and traffic assignment.

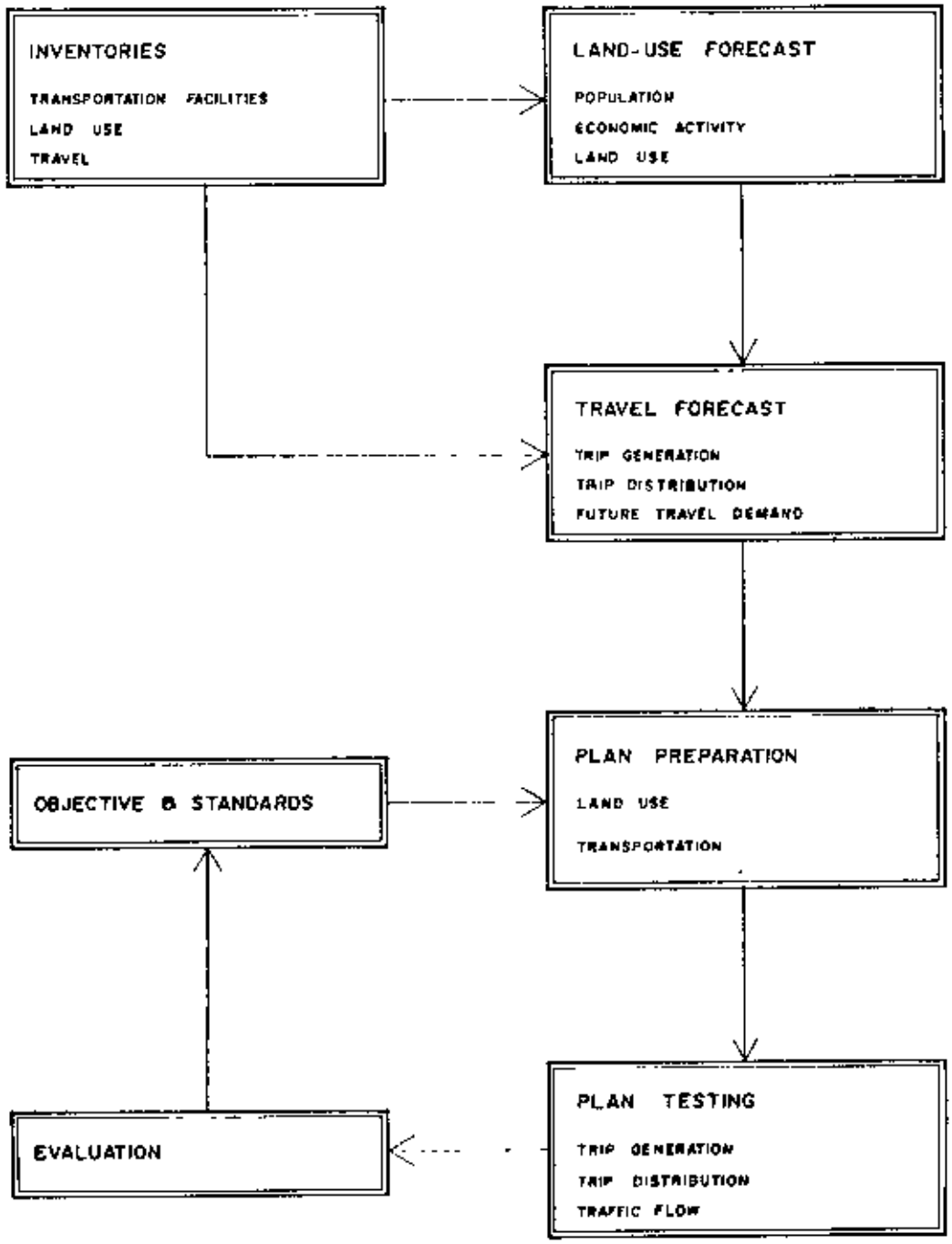
Of these, trip generation study is the fundamental and vital step in the transportation planning process. Figure 1.1 gives the principal element of transportation planning process developed for Chicago Area Transportation Study. Most of the recent studies have been organised within the same type of framework developed for Chicago Study. Trip generation stage is intended to prepare forecasts of travel demand by a geographical unit. Travel demand is used here in the restrictive sense of trip-making frequency. This is the stage of travel forecasting process where the traditional linkage between land-use and travel are introduced.

A trip can be defined as a single directional movement, for example home to work and classified into two main groups -- home-based trips and non-home-based trips. Home-based trips are those trips that have one trip end at a household and non-home-based trips are those trips between work and shop and business trips between two place of employment (Hutchinson, 1972).

This research was intended to deal with the home-based trips and to study the travel characteristics and travel behaviour. It also attempts to develop models for predicting home-based trip generation. These trips are of primary interest because eighty to ninety percent of all trips have a beginning or an ending at home and they

FIGURE [illegible]

THE TRANSPORT PLANNING PROCESS



SOURCE : HUTCHINSON [1972]

provide the direct relationship to the characteristics of tripmakers i.e. of the household (Bruton, 1970).

Total number of trips generated in a given areal unit is related either to the average measures of the characteristics of the household in that unit or to the aggregated characteristics of the unit itself. The geographical unit is generally characterized by land-use activity or intensity measures, while households are identified by certain "Socio-economic" data.

The purpose of this study is to offer a beginning framework for continuing trip generation analysis and a basic ingredient for the transportation planning process of Dhaka City. Dhaka City includes the Dhaka City Corporation area and the Cantonment area.

1.2 Statement of the Problem

Transportation is widely acknowledged as an essential infrastructure to promote socio-economic conditions of a country as well as of its urban areas. Transport situation in our urban areas, especially in Dhaka City, has increasingly worsened to the greater consternation of its citizens.

The existing road-street system and available vehicular mode of travel are deficient in many respects. The inhabitants of Dhaka City continue to suffer a great deal due to the inadequacy of walkways, uncontrolled land-use configuration and traffic generating developments and inadequacy of traffic management system. The roadway street facilities have never been conceived comprehensively nor any effort has ever been made to plan and evaluate the road-street system scientifically in consonance with the well developed process of trip generation, distributions, modal split and trip assignment.

1.3 Rationale of the Research

It may be mentioned here that a few studies were performed regarding basic transportation planning process. "An attempt was made in 1983 under the title "Socio-economic Correlates of Urban Travel Pattern: A case study in Dhaka" by Hasmat Ara. In this study, the authress tried to find out the social and economic factors related with urban travel pattern and their relationship that influence the choice of particular transport mode(s). Six neighbourhoods were selected to represent social and spatial variations within Dhaka City. Two neighbourhoods were chosen to represent each of the three existing social groups (upper, middle and lower social classes) and equal sample households were taken from each groups. Besides, various parameters those define and influence trip pattern or modal choices -- such as socio-economic status, car ownership, public transport efficiency etc. change along the span of time. So it is necessary to study the travel behaviour of urban dwellers of a City after five to ten years interval.

In large urban areas, transport planning is usually based on a transportation study -- a means of predicting future travel movements. A transport study is basically a computer dependent mathematical process founded on present day observation, whereby future travel pattern can be predicted (Wells, 1976). In this study a careful attempt was made to develop home-based trip generation models for Dhaka City and to analyse household travel behavioural pattern through statistical techniques.

1.4 Objectives of the Research

The following are the main objectives of the study :

i) To study the travel behaviour and the travel characteristics (viz: trip rate, mode of travel, trip purposes, time of the day, time required to make a trip, cost required etc.) Dhaka City.

ii) To study the inter-relationships of trip generating variables of the City.

iii) To develop home-based trip generation models for Dhaka City.

1.5 Organization of the Thesis

This thesis was separated in seven chapters. Chapter One is the introductory chapter. Chapter Two of the research presents the methodology and design techniques employed in this research. Chapter Three describes the urbanization in relation to trip generation in Dhaka City. Demographic and socio-economic characteristics of the study area is presented in Chapter Four. Detail analysis of travel behaviour and travel characteristics of the urban dwellers of Dhaka City are described in Chapter Five. Trip generation model calibration is outlined in Chapter Six. This research concludes in Chapter Seven with packages of recommendation.

CHAPTER II

CHAPTER TWO

RESEARCH METHODOLOGY AND DESIGN

2.1 Introduction

Methodology describes the procedures to be followed to operationalize the research design for the collection and analysis of information and data in conformation with the research. Dhaka City was selected as the study area. Two stage sampling procedure were adopted in selecting the sample areas and households.

In selecting residential location, cross classification technique was used considering socio-economic status (upper, middle and low income groups) and distance from the city centre (long, medium and short distances). The "Zero Point" near General Post Office (GPO), Dhaka, demarcated by Dhaka City Corporation, was taken as the city centre. From each category one or more areal unit(s) was/were selected at random. Basic data for the purpose of the study in relation to socio-economic classification, spatial distribution pattern of various income (or socio-economic) groups, detailed data on landuses, land tenure pattern, residential density pattern and other residential characteristics were obtained from the published articles. Sub-housing system of the Dhaka City is categorized into three major income groups :

i) The upper income group
ii) The middle income group
iii) The low income group

The low income group includes the hard core (or extreme poor) and the poor. Income groups and proportion of total households in the city under the three major income groups are shown in the following Table:

Table-2.1 :

Distribution of income groups in Dhaka City

* Income Group	** Income Level (monthly household income in Taka)	Proportion of the total household in the city (percent)
Low Income Group	Below Tk. 5000/-	70
Middle Income Group	Tk. 5001/- to Tk. 25000/-	28
Upper Income Group	Tk. 25001 and above	2

* Income refers to income from all possible sources including fringe benefits for an average household of six members.

** Adjusted figures in 1990 considering inflation and other income indicator.

Source: ISLAM, 1989.

2.2 Selection of the Sample Areas

Twenty one areal units were selected at random for this study. Following areal units were taken as study area -- Gulshan, Dhanmondi, Siddeswari, Mohammadpur, Pallabi, Kafrul, Khilgaon (Block-C), Gandaria, Nayapaltan, B.C.C. Road, Mirpur section two, Badda, Hazaribag lane, Muradpur, Dhamalkot (in cantonment area), Mugda, Shahid Nargar, Tejgaon I/A, Goran (Sipai bag), Fokira Pool and Sikkatuli lane of Nazira Bazar. Selected areal units were shown in Table-2.2 and Figure 2.1 and 2.2.

Table-2.2:

Distribution of areal units by income level and distance form the City Centre

Income Level / Distance from the City Centre	Upper Income Group	Middle Income Group	Low Income Group
Long Distance (5.1 km & above)	Gulshan	Mohammadpur Pallabi Kafrul	Mirpur-2, Badda (North) Hazari bag lane Muradpur, Dhamalkot
Midium Distance (2.1 to 5.0 km)	Dhanmondi	Khilgaon Gandaria	Mugda (South) Shahidnagar, Tejgaon I/A,Goran
Short Distance (0 to 2.0 km)	Siddeswari	Nayapaltan BCC Road	Fakirapool, Sikkatuli lane of Nazira Bazar

2.3 Determination of Sample Size

A sample is any subset of sampling units from a population. The size of the sample is properly estimated by deciding what level of accuracy is required and hence, how large a standard error is acceptable. It also depend on the objectives of the research. There are various common misconceptions about the necessary size of a sample. One is that the sample should be a regular proportion (often put at 5 percent) of the population; another is that the sample should total about 2,000; still another is that any increase in the sample size will increase the precision of the sample results. No such rule-of-thumb method is adequate (Machmias and Nachmias, 1976).

Travel is an expression of an individual's behaviour and as such it has the characteristics of habitual pattern. As a habit it tends to be repetitive and the repetition occurs in a definite pattern. In addition, travel habits of different individuals are similar for work, shopping, recreation and other types of trips (Bruton, 1970). Because pattern of movement exhibit these characteristics, it is not necessary to obtain travel information and data from all residents of the area under study.

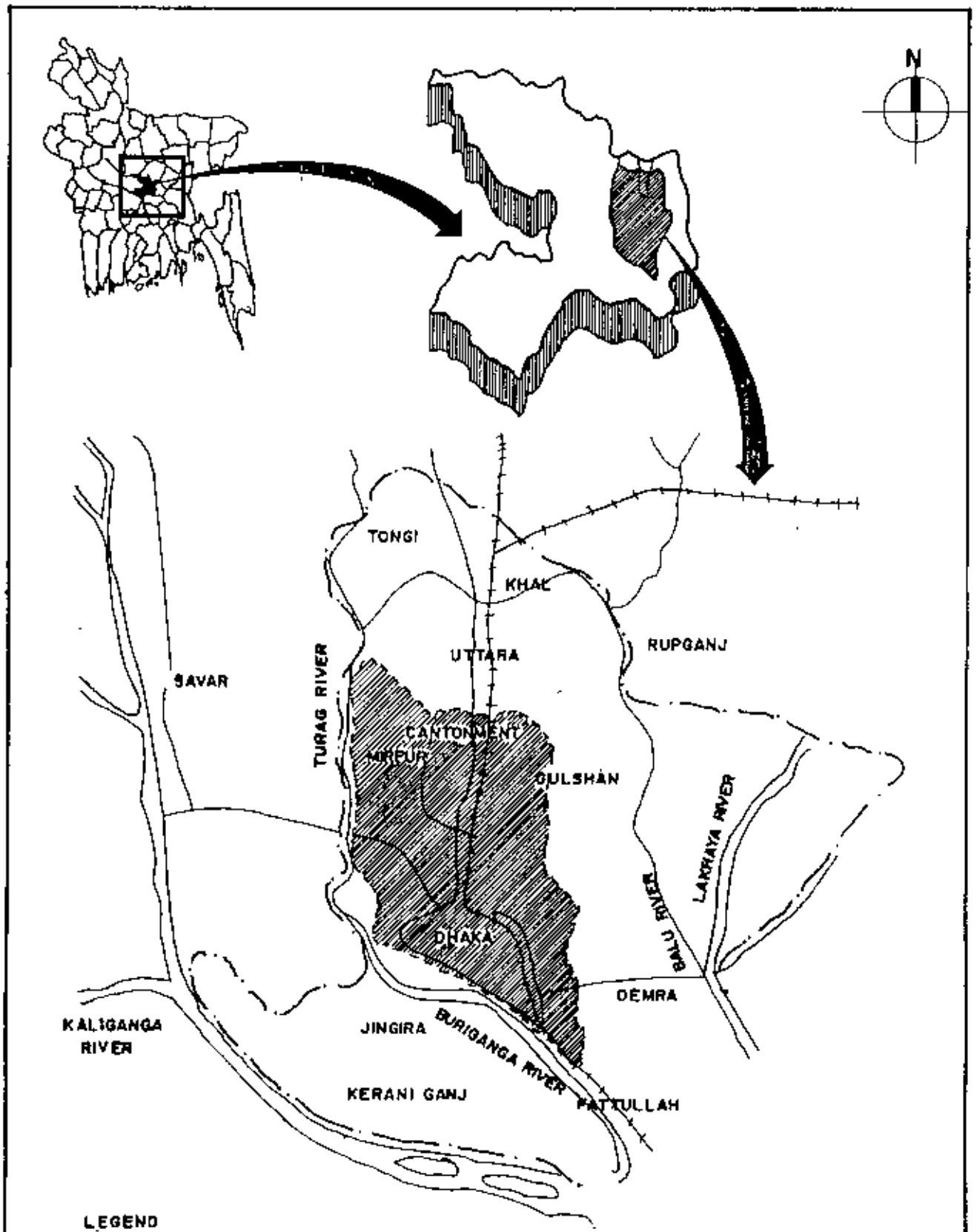
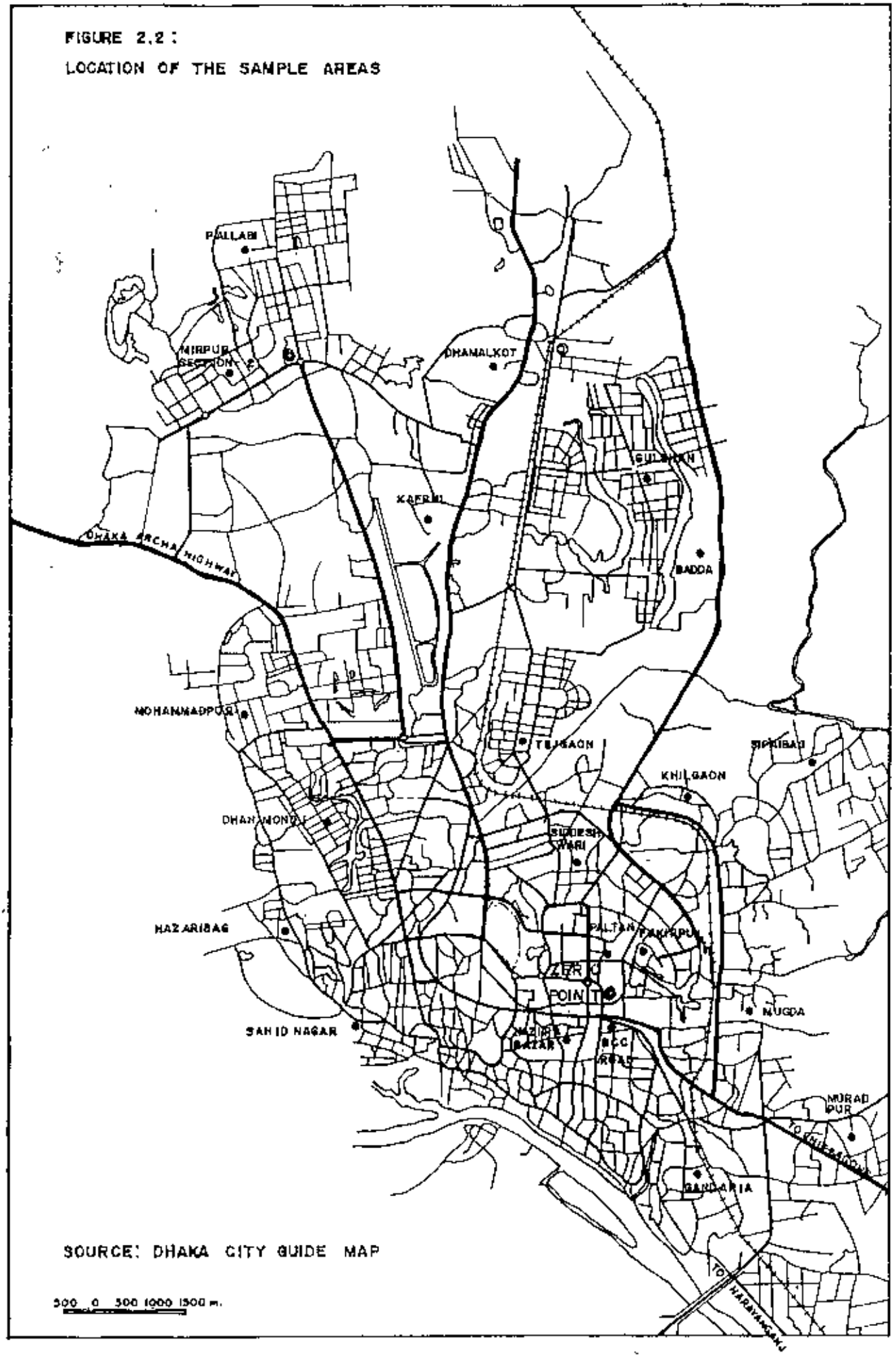


FIGURE - 2'1:
LOCATION OF STUDY AREA

FIGURE 2.2 :

LOCATION OF THE SAMPLE AREAS



SOURCE: DHAKA CITY GUIDE MAP

"Large samples" are needed to collect new travel data for the first time in an urban area. But "small samples" may be adequate for certain types of analysis, including estimates of area-wise travel characteristics, such as total trips by purposes and modes, trip length frequency distribution, trip generation relationships at the dwelling unit level and some other trip generation relationships. ..... a small sample may range from 600 to 3500 interviews for the entire metropolitan area (Norman et, al, 1973).

If cost, time and other practical limitation do not enter into decision about the sample size, there is no difficulty in determining the desired size by using standard formulas (Machmias and Nachmias, 1976). In deciding the sample size for this study researcher had to consider the basic limitation i.e. cost, time and some other practical problems. The size of the sample for this research was 775. Instead of selecting a fixed percentage of samples in each zone, a fixed number of samples was selected. For the general travel data studies 30 to 35 samples per zone are sufficient (Normal et, al. 1973).

For this study 30 to 40 samples per areal unit were selected in conformation with the proportion of the household lie in those groups but two percent of 775 for the upper income group is very small number, about ten percant was taken for the precision and representativeness of this income group. Proportion of the samples from the different income category were given below:

Table-2.3:

Proportion of household taken from different income group

Income Level	Number of sample household from each zone	Number of sample area	Number of sample household	Percentage of sample household
Upper Income Group	30	3	90	11.5
Middle Income Group	35	7	245	31.5
Low Income Group	40	11	440	57.0
Total	-	21	775	100

2.4 Selection of Sample Households

Sample households were selected systematically by using holding numbers of the sample area, collected from Dhaka City Corporation. Every 10th holding number was chosen in the selected area. Whatever may be the number of households in the sample holding number, only one sample household was taken from each sample holding number. The sample of residential buildings not occupied as family dwelling units, such as hotel, boarding houses or messes were not considered. In that case next dwelling unit was taken as the sample household. Floating people were also not considered as sample dwelling unit.

2.5 Biases in Sampling/Data Collection and Measures against them

It is essential to ensure that the sample to be drawn from the population should be representative. A sample is said to be representative if the analyses made on its sample units produce results equivalent to those that would be obtained had the entire population been analysed (Machmias and Nachmias, 1976). A sample in which all of the population is not represented or is not represented fairly -- is called a "biased sample". In technical terms, sampling bias is one of the two sources of difference between the sample estimate and the population parameter. If the difference is zero then it is termed as unbiased. The term "unbiased estimate" refers to the fact that as one draws more and more samples from the same population and finds the mean of all these unbiased estimates, the mean of these unbiased estimates approaches the population value.

Even with the unbiased estimates in probability sampling, errors of measurement and non-responses may produce biases. Biases may occur by oversight or failure to locate some of individuals or their refusal to answer the questions when located. The measuring device may be biased or imprecised. With human population the respondent may not give accurate information or they may give biased answers. Biases may also occur in editing, coding, tabulating the results.

Necessary steps were taken to avoid sampling biases. At the beginning of field survey all the interviewers were briefed with the importance of this research work

with special emphasis on correctness and completeness of data required. Besides after completion of the survey work the researcher visited two/three households, already surveyed, to check the consistency of collected data. Interviewers tried to convince and explain importance of this survey work to the household members to cooperate and to give required information. In case or refusal they collect data from the next household. If the spot checks indicated that in-adequate data or poorly chosen sample then a modified sample was chosen and resurveyed.

Extensive edit checks were carried out manually each an every completed form during the period of field survey to reduce data entry errors. Edit checks were performed on each variable as it was entered into the relevant field. All possible measures were taken to avoid biases in editing, tabulating, coding etc.

2.6 Collection of Information

The information required for this research were the basic household characteristics and all the trips made by the each member of the household of five years of age and above in previous twenty for hours.

The household information gathered includes name of the head of the household/ contact person, address of the dwelling unit, family size, person employed, monthly household expenditure, type of dwelling unit, ownership of residence, monthly household income, vehicle ownership, type of vehicles, age & sex structure of the occupants, education level, occupation and the date.

The information required from each member of the household of five years of age or more, about all the trips made in the previous twenty four hours includes the trip type, time of the day, journey time, trip length, mode of travel, reasons for using this mode, cost required and trip purposes.

These information are usually gathered through interviews in the dwelling unit. There are a number of interview methods available to collect information from the dwelling unit.
These are:

i) Home Interview method.

ii) Mail Questionnaire/Post Card method and

iii) Telephone Interview method.

i) Home Interview Method: In this method interviewers visit the sample dwelling unit(s) and collect information required asking question directly to the household members. Interviewers can explain about any querries regarding the research work. It is a widely used method to collect household information.

ii) Mail questionnaire method: Questionnaires can be sent through mail; it is cheaper than home interview. It reduces biases errors that might result from the personal characteristics of interviewers and variabilities from their skills. But reported response rates are much lower than from home interview.

iii) Telephone Interview Method: In this method collection of required information is by telephone, and normally it is not recommended in the developing countries because only a few people have telephone.

In this research information was collected from the sample dwelling unit by using home interview method because it is much effective and advantageous over the other methods.

Interviews were conducted daily (Saturday - Thursday) between 17:00 -21:00 and on Friday morning between 8:00 A.M. - 12:00 Noon. During these hours most of the household heads and other family members (tripmakers) were available for interview.

The head of the household is defined as the prime income earning member of the household and not necessarily the eldest male member. Survey was performed only if the household head was present and gave consent to an interview, other wise the survey assistant moved to the next house or flat in his allotted areal unit. Except for the upper income area all the households were very much receptive and cooperative. If a member of the household was not present the information was

sought from the household or housewife.

Though it was not fixed throughout the entire period of the survey work but most of the time, the total survey team worked in the field level comprised of eight interviewers suppervised directly by the researcher himself. The said strength was divided in eight working groups. All of the interviewers were at least graduate or its equivalent while three of them are URP students. All the member of survey team were briefed in detail with a special emphasis on objective of the research, importance of correct and accurate data, understanding of the forms, completeness of data etc. by the researcher before commencing the survey. They performed pilot works before going to the study area. Thirty days were required to complete the field survey.

The researcher visited the sample areal units at least one/two day prior to the actual survey to correctly identify the location and have a preliminary assessment of the households in the area and to select the household to be surveyed. The researcher also visited each day during the survey work to check and guide the interviewers at random.

Initial scrunity and subsequent checking were done carefully and regularly after receiving the completed forms on each day during the survey work by the researcher. Checking was done manually.

2.7 Analysis of Information

Collected information and data from the sample areal units were then stored in the computer. Package program -- SPSSx (Statistical Package for Social Sciences) was used for data entry. SPSS is the proper package for preparation of summary cross tables, regression analysis and other statistical analysis. Screen templates were designed to facilitate the data entry directly from survey form into their respective data files. Initially data files were prepared in respect of each sample area then compiled whenever necessary. The survey data from each sample area was entered directly into its database file with the help of screen form. During the data entry phase of the surveys there were constant checks on the actual data entry.

Harvard Graphics - one of the most advanced package program for graphical presentation was used to prepare bar-chart, pie-chart -- all coloured and three-dimensssional.

2.8 Model Calibration

Package program -- SPSS was used to calibrate the transport models. Multiple linear regression models were calibrated to develop the required models. Trip generation models employ the concept of regression analysis. Multiple linear regression analysis is the statistical technique, now extensively used to derive estimates of future trips generation, where two or more independent factors were assumed of simultaneously affecting the amount of travel.

2.9 Literature Survey

A survey was carried out on works relevant to the subject of the research were spread throughout the large number of journals, books, reports, newspapers articles etc. Information on trip generation as well as transportation planning of Dhaka City was hardly available. Search was also carried out intensively to gather a proper understanding about the standard of different community facilities.

Experience of many developed and developing countries in related fields was reviewed to understand the extent of the problem in Dhaka and to perceive the prospects considering various inputs and constraints.

2.10 Conclusion

Dhaka City was selected as the study area. Twenty one areal units were selected as the sample area at random considering the socio-economic status and distance from the City Centre. Size of the sample households were 775 Nos. From each of the areal units 30 to 40 households were interviewed systematically through coded questionnaires. Sample households were selected by using holding numbers -- only one sample household was taken from each sample holding number. Collected information and data were then stored, analysed and calibrated to achieve the objectives of the research.

CHAPTER III

CHAPTER THREE

URBANIZATION AND TRANSPORT IN DHAKA CITY

3.1 Urbanization

Dhaka City is the capital city of Bangladesh and it contains the central offices of all government ministries. It is the administrative, financial and commercial centre of the country. It is served by an international airport near Tongi, a river port at Sadarghat, three inter-district bus terminals at three entry points of the City, and an extensive interurban rail service and highway networks. The existing infrastructure provides a firm-base for further expansion.

The population of the City has been increasing steadily. Estimated population of Dhaka City is now about six million, crowded in an area of 402.50 Square Kilometer (B.B.S, 1981). The Dhaka City Corporation area which hold most of the population of the City has a density of over 22000 persons per square kilometer (58000 persons per square mile). With the area adjustment and considering other related factors population growth rate in the City has been found to be approximately 6.0 percent per annum in the last intercensal period (Islam and Nabi, 1988).

3.2 Motorization

There are approximately 63 thousand motorized vehicles (excluding motor-cycles) operating in Dhaka City. As shown in the Table-3.1, the level of motorization in the City is about 12 vehicles per 1000 population, which is very low while comparing with the other capitals of the developing countries.

Table-3.1:

Motorized vehicles now operating in Dhaka City

Category of Vehicles	Number of Vehicles	Percent (%)
Bus	350	0.55
Mini-bus	635	1.00
Cars	35000	55.30
Jeep	12000	18.96
Micro-bus	1850	2.92
Taxi/Cars	263	0.42
Auto-rickshaw	6500	10.27
Mishuk	750	1.18
Pick-up	1600	2.53
Tempo	1350	2.13
Truck	3000	4.74
Total	63298	100.00
Motor-cycle	58000	-
Motorization (Vehicles growth Rate)	12	-
Vehicles growth Rate	6.5%	-

Source: Office of the Deputy Commissioner (Traffic) December 30, 1989.

Vehicles growth rate over the past five years in the City has been also low. Table-3.1 disclosed that vehicles growth has increased at about 6.5 percent per annum over the past five years.

Because of the low level of private motor vehicle ownership public transportation should play a very important role in the daily life of the City dwellers. Therefore, the demand for adequate public transportation is very strong in the City. Due to inadequate public transportation and chaotic roadway and street system cycle-rickshaws (non-motorized vehicle) have been rendering door to door services to the urban dwellers. As the City become larger and the distance between home, work places and community services get longer, this alternative mode of transport has becomes less feasible.

Transport models in developed countries/western cities divide trips into public

transport and private motor vehicles trips. This is acceptable where non-motorised trips are negligible and have practically no effect on road traffic. But in Dhaka City non-motorized traffic serves a very large proportion of person trips and also impacts significantly on road network performance.

3.3 Road Network of Dhaka

Dhaka is a fast growing metropolitan City, presently being served by a roadway and street facilities comprised of over 1200 miles. An estimate of 70 percent of these road facilities are within the metropolitan area (Haque, Ahmad, 1988). Historically, the City has grown by the process of "gradual accretion". As a consequence the City has grown in a disorganized manner and its road and street system has also developed haphazardly. As a result, a kind of unbalanced traffic flow has incurred. To be more specific, certain links of existing road-street system is under heavy vehicular pressure (volume-wise), while others are lightly travelled. The existing road-street system is unbalanced in the sense that mileage constituting the "City Major Thoroughfare System" is less than 5 percent of total mileage (Haque, 1988). In order to develop a "balanced network" suggested standards for major urban arterials comprising the major thoroughfare systems are of the order of 8 percent to 12 percent of the total mileage (Traffic in Towns, 1963).

Due to the uncontrolled influx of people and increase in their activities, the quantum of movement has increased significantly. But transportation services and facilities did not augmented with equal pace resulting a demand-supply imbalance, indisciplined and haphazard movement has become a common phenomenon.

3.4 Landuse Pattern in Dhaka City

Traffic is a function of landuses. In other words, traffic generation, traffic volume, movement frequency, traffic capacity, need for parking facilities etc. depend on the type of uses of land on the sides of roadway. Residential, commercial, industrial and recreational are four major land use types found in the urban areas and they determine the volume of traffic and their behavioural pattern. It was previously stated that for a long time Dhaka City has been experiencing unplanned growth.

Both private and public developments such as housing, health facilities, educational institutions, shopping centres etc. at particular sites can not be regarded as the product of proper planning.

Besides this, landuse pattern of the city has undergone changes over the recent past. With the natural expansion of the City, commercial and industrial zones are no longer concentrated in the central area, rather different activities are now developing in locations more accessible than the central areas.

The continuous changing pattern of landuses ensued changed in the travel pattern and in the trip making frequencies of the urban dwellers of the City.

3.5 Public Transport in the City

Like many other Asian Cities, the present pattern of public transportation services in Dhaka City consists of fast moving motorized vehicles and primitive non-motorized slow moving vehicles, in addition to the pedestrians. The available mode of travel at present in the City are motorized bus, mini-bus, auto-rickshaw, tempo, mishuk, motor bike and non-motorized rickshaw, bicycle etc. Among all these types rickshaw, the slowest of all the modes, generally does not make any long-haul trip. Auto-rickshaw makes longer haul but they are expensive. The minibus is a smaller version of the bus having higher fares that of buses. The bus is a popular mode of public transport with least unit fare for longer trips.

The very widely diversified traffic units with their great disparity in sizes and speeds create a number of problems and areas of conflicts. Because of the low speed of certain types of vehicles, the capacity of roads is adversely affected and severe congestions and accidents occur.

3.6 Conclusion

Dhaka City is the administrative, financial and commercial centre of the country. It is one of the densely populated City in the world with a growth rate of 6.0 percent per annum. For a long time Dhaka City has been experiencing unplanned

growth. It has grown in a disorganised manner and its road-ways system has also developed haphazardly.

Because of the low level of motorization, non-motorized vehicles plays an important role in the daily life of City dwellers. Traffic is a function of landuses. Landuse pattern of a City determine the volume of traffic and their behavioural pattern. Changing pattern of landuses ensued changes in the travel pattern and in the trip making frequencies of the urban dwellers of the City.

CHAPTER IV

CHAPTER FOUR

BACKGROUND CHARACTERISTICS OF THE CITY DWELLERS

4.1 Introduction

Travel is a function of human activity. Different socio-economic characteristics of the resident population produce different movement pattern. Relevant and useful items of information on the demographic and socio-economic characteristics of the resident population were presented in specific sub-sections.

4.2 Demographic Characteristics

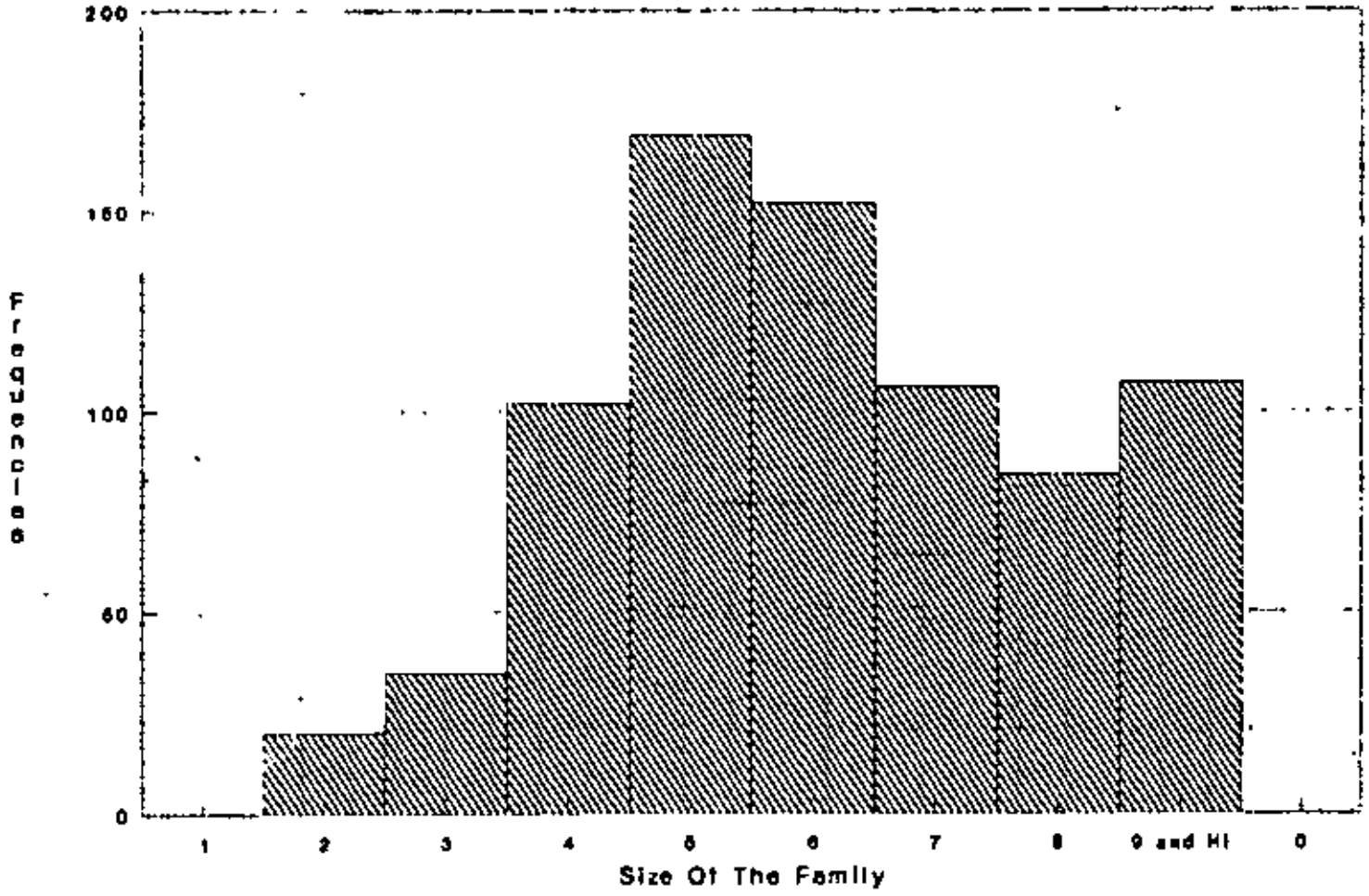
To study any population for any purposes, it is essential to have knowledge regarding the demographic characteristics about that population. Particularly in this case demographic characteristics of a household plays a vital role in making trips. In this section information related to family size, age, sex of the tripmakers were given.

The average size of the household of Dhaka City consists of 6.07 persons with a standard deviation of 1.83, ranges two persons to nine(+) persons. Figure-4.1 shows the distribution of family size of the sample population which is distributed normally. The average number of employed persons per household is 1.56 with a standard deviation of 0.86. Table-A1 presents the summary statistics of these attributes.

4.2.1 Age Structure of the Tripmakers

The age structure of the population is often taken into consideration in trip generation analysis on the basis that different age groups produce different movement demand and characteristics (Bruton, 1970). Tripmakers belonging to different age groups were classified in the following Table-4.1.

Figure 4.1 :
Distribution of the Family Size of the Tripmakers



Source : Field Survey, December 1999

Table-4.1:

Age distribution of the tripmakers

Category Level (yrs.)	Number of Respondent	* Percent of Responses	** Percent of Dhaka Population
6 to 15	809	30.2	30.1
16 to 25	744	27.7	24.9
26 to 35	477	17.8	20.6
36 to 45	328	12.2	12.2
46 to 55	248	9.3	6.7
56 and above	74	2.8	5.5
Total	2680	100.00	100.00

Source: * Field Survey December, 1989.
** Population Census 1981, BBS.

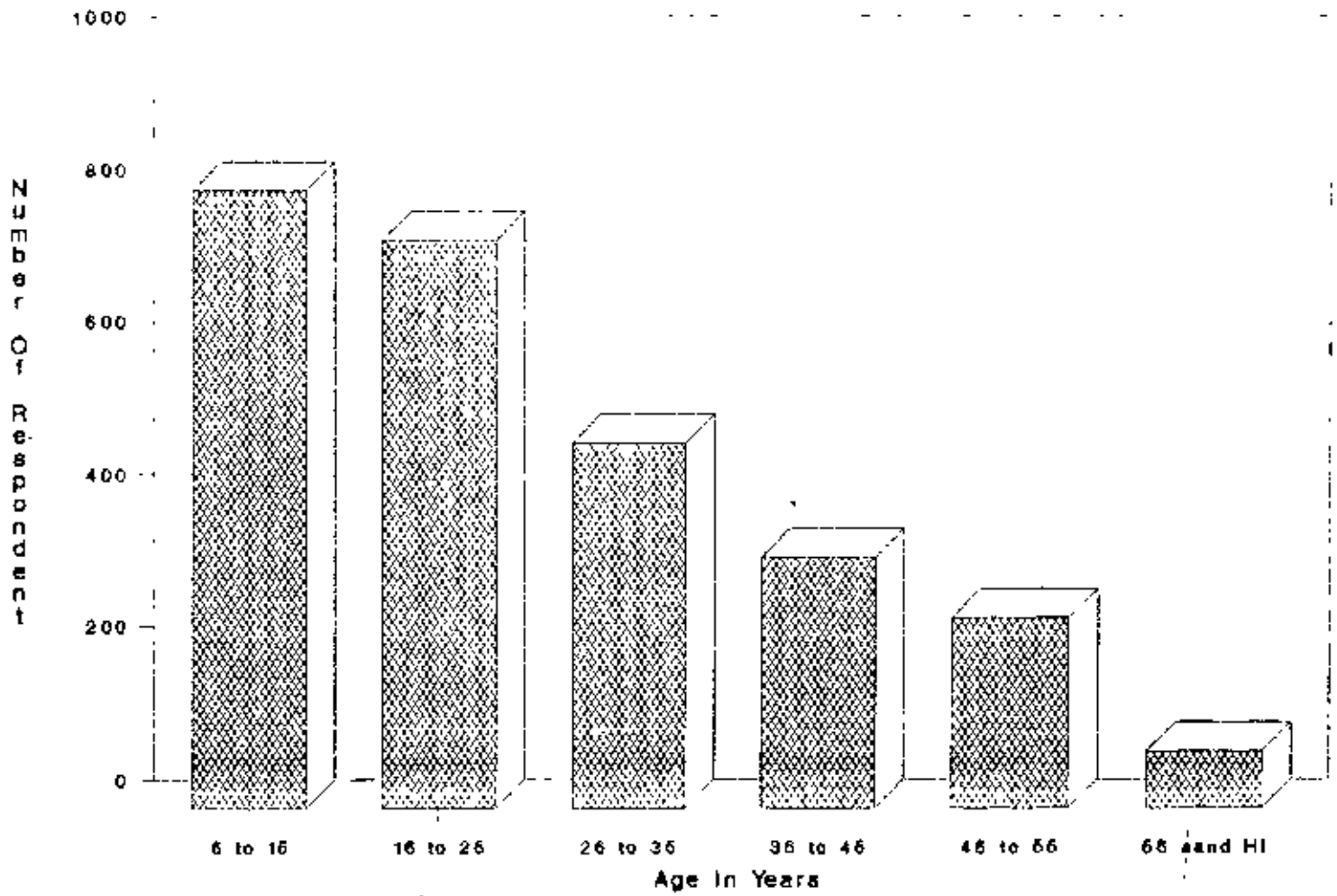
From the preceding table it can be easily seen that most of the tripmakers are young irrespective of occupation. They make more trip than the old age people. About fifty eight percent of all tripmakers fell into the 6 to 25 year age group. On the other hand, among the 5.5 percent of the 56 and above age group (actual portion of Dhaka population) only 2.8 percent of that age group made trips. That was because of their physical inability to make trips. Figure-4.2 shows that as age of the respondent increases the number of tripmakers decreases.

4.2.2 Sex Structure of the Tripmakers

The Table-4.2 shows that male were prone to make more journey. About sixty nine percent of the tripmakers were male where a thirty one percent of the tripmakers were female. The sex ratio of the tripmakers is 2.25. In contrast with the population census of 1981, percentage of male and female of Dhaka's population were 58.2 percent and 41.8 percent respectively and the sex ratio was 1.39. These figures disclose the fact that male population perform more activities than female.

Figure 4.2 :

Age Distribution Of The Tripmakers



Source : Field Survey, December 1989.

Table-4.2:

Sex Distribution of the Tripmakers

Sex	Number of Respondent	Percent of Responses	Percent of Dhaka Population
Male	1854	69.2	58.2
Female	826	30.8	41.8
Total	2680	100.00	100.00

Source: Field Survey December, 1989.

From the Table-4.3 it can be seen easily that in case of category 26 years and above percentage of same aged males make more trips than females. It is much true as age increases.

Table-4.3:

Distribution of Age of the Tripmakers by Sex

Sex Age (yrs.)	Male	Female	Total
6 to 15	449 (55.5%) (24.0%)	360 (44.5%) (44.0%)	809 (100%) (30.0%)
16 to 25	516 (69.0%) (28.0%)	228 (31.0%) (28.0%)	744 (100%) (28.0%)
26 to 35	358 (75.0%) (19.0%)	119 (25.0%) (14.0%)	477 (100%) (18.0%)
35 to 45	244 (74.0%) (13.0%)	84 (26.0%) (10.0%)	328 (100%) (12.0%)
46 to 55	221 (89.0%) (12.0%)	27 (11.0%) (3.0%)	248 (100%) (9.0%)
56 and HI	66 (89.0%) (4.0%)	8 (11.0%) (1.0%)	74 (100%) (3.0%)
Total	1854 (69.0%) (100%)	826 (31.0%) (100%)	2680 (100%)* (100%)**

Source: Field Survey December, 1989.
* Row-wise percentage
** Column-wise percentage

4.3 Socio-economic Characteristics

Socio-economic characteristics of the population have significant influence on travel behaviour and tripmaking frequency. Particularly education and occupation of the tripmakers and monthly household income.

4.3.1 Monthly Household Income

Household income was one of the most important factors having major effect on trip generation. It is the prime factor responsible for shapping travel behabivour and determining its characteristics such as trip rate.

It was stated earlier that monthly household income were broadly classified into three major groups: low income group, middle income group and upper income group. The following Table-4.4 shows the distribution of household income of the respondents.

Table-4.4:

Distribution of monthly Household Income

Income	Category (Tk.)	Frequency (f)	Percent of Responses	Percent of Responses
Low Income Group	Below 2000	49	6.3	52.00
	2001 to 3000	180	23.2	
	3001 to 5000	174	22.5	
Middle Income Group	5001 to 10000	144	18.6	31.00
	10001 to 15000	64	8.3	
	15001 to 25000	39	5.0	
Upper Income Group	25001 to above	125	16.1	16.00
Total		775	100.0	100.00

Source: Field Survey December, 1989.

It can be seen from the preceding Table that 52.00 percent of Dhaka's total population fell into low income group (below Tk. 5000). Where as 31.9 percent and 16.1 percent of the total population fell into middle and upper income groups respectively. Relationship of household income with other attributes will be discussed in the following chapters.

4.3.2 Level of Education of the Tripmakers

The Table-4.5 shows the education levels of the tripmakers. About ninety four percent of the all tripmakers were literate. Literacy rate of urban Dhaka is 52.2 percent (BBS, 1981). The discrepancy is probably because of methodological assumption, for this study floating people were not included in the survey.

Table-4.5:

Educational Level of the Tripmakers

Category Level	Frequency (f)	Percent of Responses
Primary	610	22.8
Secondary	816	30.4
H. Secondary	515	19.2
Graduation	598	22.3
Illiterate	141	5.3
Total	2680	100.00

Source: Field Survey December, 1989.

4.3.3 Occupational Characteristics of the Tripmakers

Occupation of the tripmakers had a significant effect on travel characteristics. Students constituted the highest portion of the tripmakers (Table 4.6). About 50 percent of all tripmakers were students. Self-employed persons constituted the second largest group of tripmakers. These result indicated that significant increase in the recent years in entrepreneurial activities in Dhaka City as well as in the country.

Table-4.6:
Occupational Pattern of the Tripmakers

Category Level	Frequency (f)	Percent of Responses
Professionals	115	4.3
Adn. & Management	92	3.4
Student	1224	45.7
House wife	185	6.9
Clerical & Related	253	9.4
Self Employed	358	13.4
Sales and Service	77	2.9
Manufacturing and General Workers	123	4.6
Others	253	9.4
Total	2680	100.00

Source: Field Survey December, 1989.

Category level of "other" includes unemployed, retired persons as well as persons with undefined occupations. This group of tripmakers occupy the third highest position. About 10 percent of all the tripmakers fell into this category.

4.4 Relationship Between Age and Occupation of the Tripmakers

The relationship between the type of occupation and different age groups (Table-A10) shows that the proportion of tripmakers engaged in administrative and managerial works increased with the increase of their age. On the other hand proportion of the tripmakers of other occupational groups decreases as age increases. Test statistics depicts that significant relationship exist between occupation and age level of the tripmakers at almost 0.001 level of significance.

Analysis of the results (Table-A11) shows that highest proportion of the students have secondary level of education. A significant proportion of self-employed respondent have graduation degree. This indicated that due to recent governmental policies and less employment opportunities young graduates were trying to create their own job.

4.5 Conclusion

Demographic and socio-economic characteristics of a household plays a vital role in making trips. The average size of the family of Dhaka City consists of 6.07 persons with a standard deviation of 1.83, ranges two persons to none(+) persons and number of employed persons is 1.56.

This research revealed that young people, irrespective of occupation and income level, made more trips than old aged people. About 58.0 percent of all tripmakers fell into the 6 to 25 year age group. Male were prone to make more trips than female. The sex ratio of the tripmakers is 2.25. In contrast with the population census of 1981, the sex ratio was 1.39.

Household monthly income is the prime factor responsible for shaping travel behaviour. Among the major three categories, 52.0 percent of Dhaka's total population fell into low income group whereas 32 ad 16 percent fell into middle income and upper income groups. Among the different occupational groups, students constituted the highest portion (50.0%) of the trip makers. Self-employed persons constituted the second largest group of the tripmakers. Analysis showed that major portion of the student have secondary level of education. A significant proportion of self-employed have graduation.

CHAPTER V

CHAPTER FIVE

TRAVEL BEHAVIOUR

5.1 Introduction

One of the main objectives of this research was to study the travel behaviour and travel characteristics of Dhaka City at individual household level. Several variables were responsible for shapping the travel behaviour of Dhaka City and determining its characteristics such as household income, family size, location of residence, ownership of vehicle(s), purpose of trip, mode of travel, trip length, journey time, time of the day, cost of travel, etc. This chapter details the in-depth analysis of travel data to explain and describe the key variables pertinent to the tripmaking frequency and inter-relationship between different variables. Detailed analysis showing the relationship among variables were presented in the following sections.

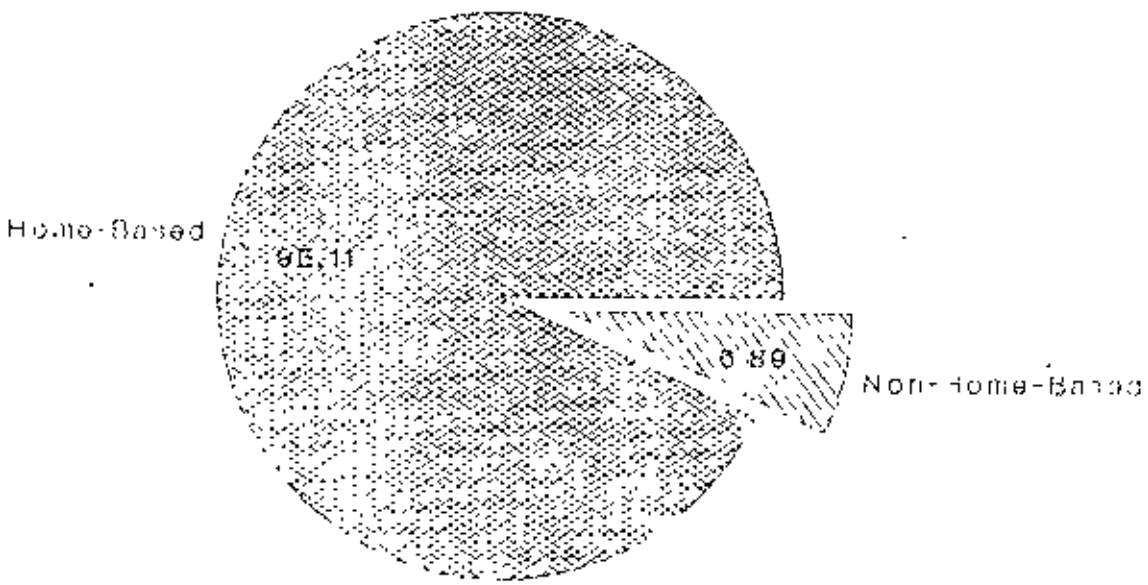
5.2 Trip Type and Trip Rate

A trip is defined as a single directional movement, for example home to work. Therefore, household member(s) undertaking such journeys make at least two trips daily, viz, from home to work and from work to home. It was stated earlier that trips can be classified into two main groups -- home-based trips and non-home-based trips. Home-based trips are those trips that have one trip end at a household and non-home-based trips are those trips between work and shop and business trips between two places of employment (Hutchinson, 1972).

Several past studies disclosed the fact that 80 percent to 90 percent of all trips have a beginning or an ending at home i.e. 80 percent to 90 percent of all trips are home-based (Bruton, 1970). This study revealed that 93 percent of all trips were home-based in Dhaka City (Figure-5.1).

Due to the rise of commercial activities in Dhaka City, the number of trips (Trips per household per day) of urban dwellers increased as compared to the trip rates of the dwellers some years before. The average number of trips per household per day

Figure 5.1
Type Of The Trips



Source : Field Survey , December 1989.

(both home-based and non-home-based) of Dhaka population was about 6.89 in 1983 (Ara, 1983). The number of trips per household per day in Dhaka City was found to be 9.43 in this study with a standard deviation of 4.18, ranging from no trips to 28 trips per household per day (Table-A1). Figure-5.2 shows the frequencies histogram of trip rates -- which is distributed normally and skewed left.

5.3 Household Income

Household income pattern of Dhaka's population was already discussed in the previous chapter. It is the key variable having major effect on trip generation. It is a prime factor which is mainly responsible in shaping travel behaviour and determining its characteristics such as trip rates. The ability to pay for a journey affects the number of trips generated by a household. Families with high income can generally afford to satisfy more of their movement demands than low income families. The number and frequency of trips generated from home increases with increasing family income. This study indicated (Table-5.1) that in Dhaka City 52 percent of low-income people generate only 42 percent of all trips made by tripmakers whereas 16 percent of upper income group and 32 percent of middle income group generate 24 percent and 34 percent of all trips respectively and the average number of home-based trips per household per day i.e. trip rate of the three income groups were 7.74, 9.94 and 13.68 respectively.

Table-5.1

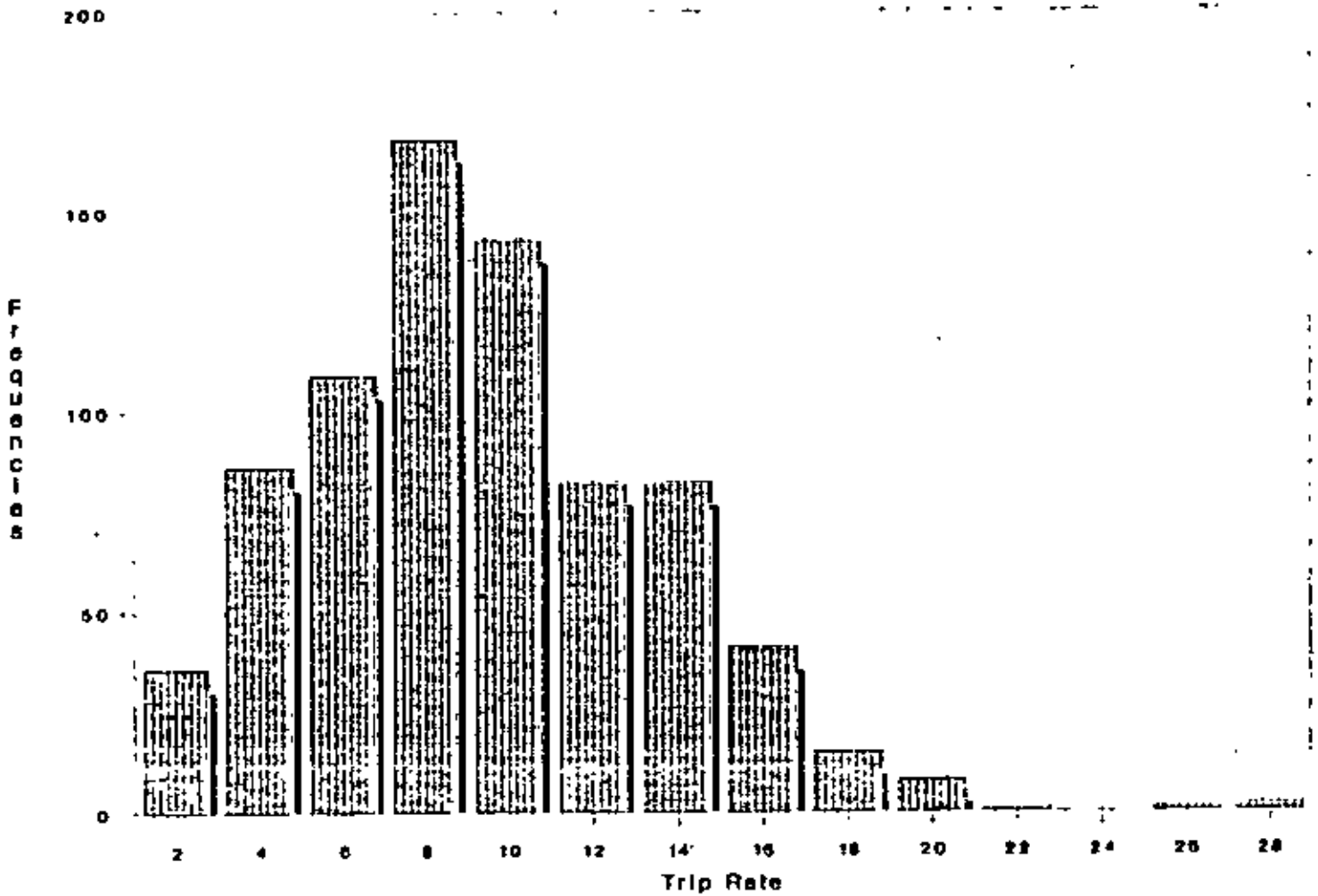
Household Income Level and Trip Rate Distribution

Household Icome	Responses (percent)	Trip Frequency (percent)	Trip Rate
Low Income	403 (52.0)	3066 (42.0)	7.74
Middle Income	247 (32.0)	2505 (34.0)	9.94
Upper Income	125 (16.0)	1737 (24.0)	13.68
Total	775 (100.0)	7308 (100.0)	-

Source: Field Survey December, 1989.

Figure-5.2:

Frequencies Distribution of Trip Rates



Source: Field Survey December 1989.

5.4 Location of the Residence

Location of the residential areal units with respect to City Centre is also a key variable which was assumed to be responsible for generating home-based trips by individual household. It was stated in chapter two that selection of residential areal unit(s) was/were based on their location i.e. the locational distance from the City Centre (short, medium and long distances). The argument for using the above factor is that the characteristics of the dwellers and development trend and hence the movement pattern vary with the distance from the City Centre. It is expected that the increase in distance from the City Centre leads to increased trips per household per day (Martin, 1962). But this study shows that trips per household per day decreases with the increase in distance from the City Centre (Figure-5.3). Probably this is because of concentration and availability of necessary establishments i.e. due to the landuse pattern of Dhaka City and also the low level of car ownership.

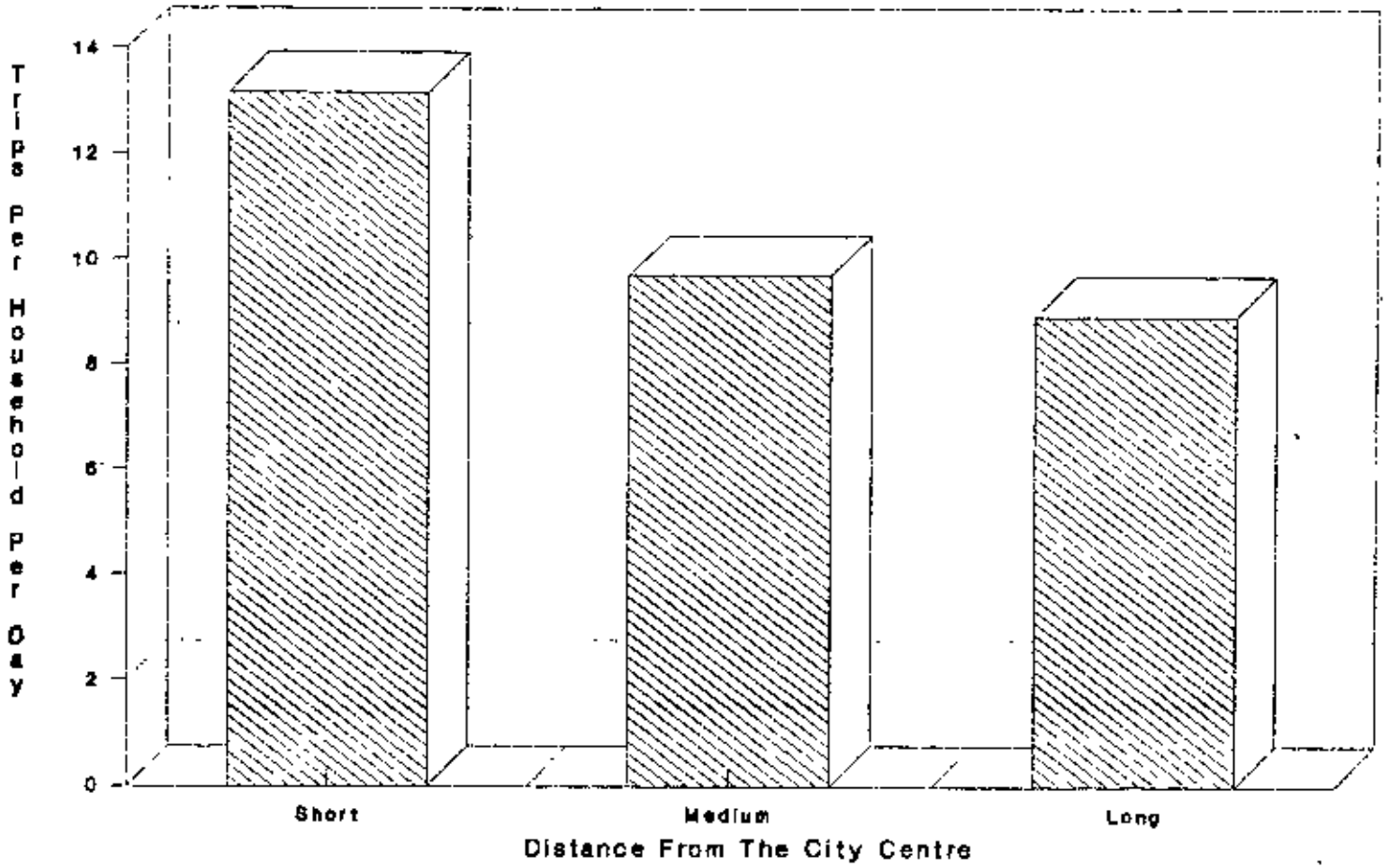
5.5 Relationship between Family Size and Home-based Trips per Household per Day (Trip Rate)

Travel is a function of human activity. Consequently an important relationship should exists between the number and frequency of trips made from the home and the family size.

The number and frequency of trips increase as size of the family increases and vice-versa. This study on Dhaka City also exemplify this fact. Table-A12 shows that average number of trips increases with increasing persons per household, at a rate of approximately 1.62 trips per day for each additional person (Table-A1). This increase in number of home-based trips per household per day with family size tends to level-off at the six persons per dwelling unit family size. Statistically strong relationship did exist between family size and the number and frequency of trips made from home at the confidence level of 99.99 percent. They are also positively correlated. These results also imply that with the increase of family size, the number of trips per household per day increases. The reverse is also true.

Figure 5.3 :

Influence Of Distance From The City Centre On Trip Generation



Source : Field Survey, December 1989.

5.6 Mode of Travel

Mode of travel is the most influential variable related to trip making frequency. Bus, mini-bus, car/jeep, auto-rickshaw, tempo, rickshaw etc. are the available modes now operating in Dhaka City. Among these, rickshaw is the most popular and easily available mode of travel. It renders door-to-door services irrespective of road condition. In Dhaka City bus and mini-bus operates only on a few roads. Though personal motorized vehicle ownership will continue to rise, still walking and rickshaw are the major modes of travel in Dhaka City. From Table-5.2 can be seen that about 36 percent of all trips were made on foot, while only 25 percent of all trips were made by rickshaw. This study also disclosed the fact that a laudable portion of trips were rendered by charter bus. This is a remarkable indicator of changing pattern and behaviour of urban dwellers. Figure-5.4 presents the existing mode use pattern of Dhaka City.

Table-5.2:

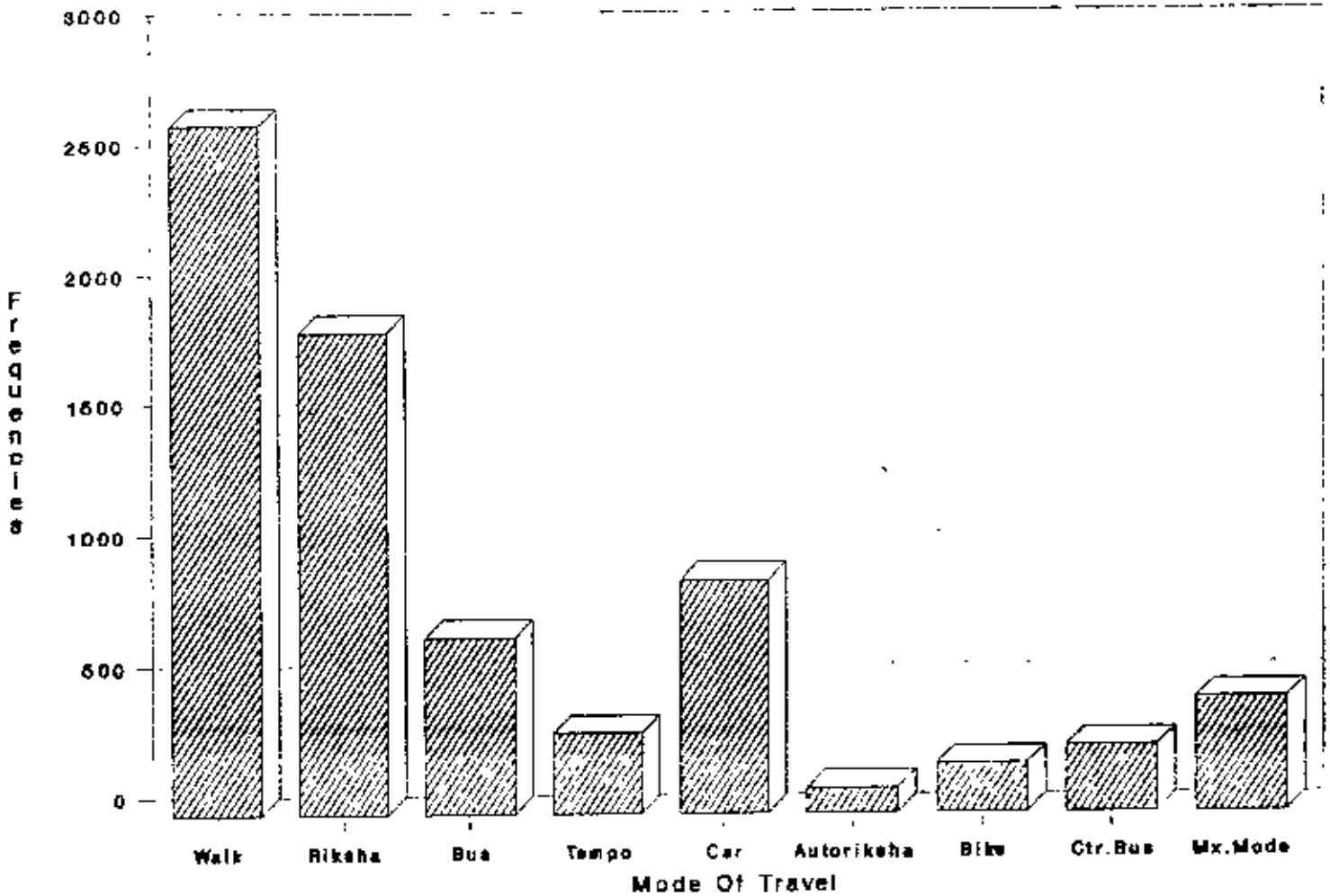
Modal Choices in Dhaka City

Mode Type	Frequency (f)	Percent of Responses
Bus	1006	14.00
Car/Jeep	887	12.00
Auto-Rickshaw	93	1.25
Tempo	387	5.50
Motor/Cycle	185	2.50
Rickshaw	1842	25.00
Walking	2639	36.00
Mixed mode *	269	3.75
Total	7308	100.00

Source: Field Survey December, 1989.

* Mixed Mode: when a trip made on more than one mode of travel i.e Rickshaw + Bus.

Figure 5.4 :
Distibution Of Mode Of Travel



Source : Field Survevy, Decemher 1989.

5.7 Purpose of the Trip

The most fundamental and dominating variable related to travel demand and travel characteristics is trip purpose. People make trips because they cannot perform all the activities in one place. Activities are normally grouped into a number of trip purposes which distinguish different types of demand on transport system. So it is essential to stratify trips by purpose throughout the transportation planning process. This in turn implies that trip generation analysis must be undertaken for different trip purposes. The number of different trip purposes used in trip generation modelling and travel demand analyses varies with the design of the individual study. For this study trip purposes were stratified in the following from :

a)	Work trips	-	home to work
			work to home
b)	School trips	-	home to school
			school to home
c)	Shopping trips	-	home to shop
			shop to home
d)	Socio-Recrea-	-	home to recreational place
	tional trips		recreational place to home
e)	Other trips	-	home to other places
			other places to home

a) Work trips: These trips includes as all journeys to and from various work places to earn money (i.e. for employment purposes).

b) School trips: School trips include as all journeys to and from various educational establishments such as schools, colleges, different technical institutes, coaching centres and universities solely for educational purposes.

c) Shopping trips: Any trip to and from any shopping centre to buy something.

d) Socio-recreational trips: All trips made for social (such as trips made to visit a patient in hospital or in his home or to meet with kith and kin etc.), religious, leisure and recreational purposes fell into this class.

e) Other trips: Any trips undertaken by the member of the household which do not fall into any of the above classes and other undefined trips are included in this group.

The following Table-5.3 shows that in Dhaka City tripmaking frequencies is the highest for work purposes. About 37 percent of all trips undertaken by the individual households were work trip while school trips, shopping trips, socio-recreational trips and others were 31.00 percent 9.54 percent, 12.44 percent and 9.76 percent respectively.

Table-5.3:

Frequencies of Trip Purposes

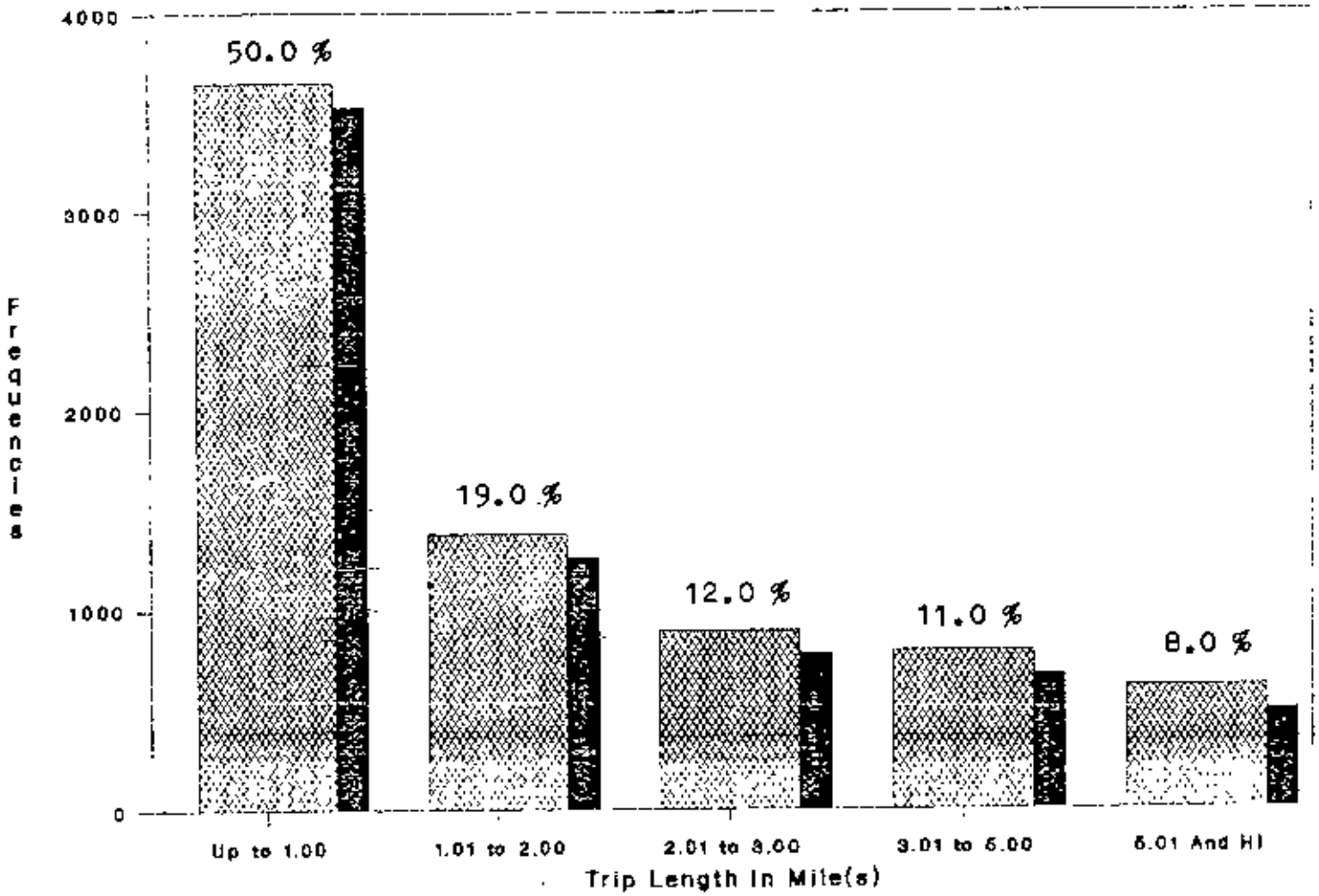
Category Level	Frequency (f)	Percent of Responses
Work Trip	2723	37.26
School Trip	2266	31.00
Shopping Trip	697	9.54
Socio-Recreational Trip	909	12.44
Others	713	9.76
Total	7308	100.00

Source: Field Survey December, 1989.

5.8 Trip Length

Length of the trip is a physical characteristic of travel this variable is a continuous one. Figure 5.5 shows that trip frequencies decrease with the increase in trip length. About 50 percent of all the trips made by the tripmakers were less than one

Figure 5.5 :
Distribution Of Trip Length Frequencies



Source : Field Survey, December 1989

mile (Table-A9). This indicates the fact that City dwellers try to reside close to their necessary destination such as workplace, school, shopping centre etc. Although other variables also influence the length of trip, those would be discussed later.

5.9 Time of the Day

Now-a-days traffic congestion is a regular phenomenon in Dhaka City. Like other major metropolitan areas, Dhaka suffers from some form of roadway congestion during peak use periods. The levels of congestion are directly related to the fact that total vehicular travel is not uniform throughout the 24 hours of the day. Traffic congestion and the associated problems of limited roadway capacity and travel delays occurred during the peak periods of the day, most noticeably in the evening hours of 5 p.m. to 8 p.m. The second and often very pronounced, short-term peak occurred in the morning hours between 8 A.M. to 10 A.M. Figure-5.6 displays the variation in trip frequencies during the day. Although Table-5.4 shows that about 25 percent of the total trips occur during the morning period of 5 A.M. to 9 A.M. but a significant proportion of the trips were locale in nature i.e. non-vehicular and short length trips. The above table also depicts the fact that a considerable portion of trips were made in the evening. This indicates that the behavioural pattern of trip making is changing in Dhaka City. The inter-relation between time of the day and other trip generating variable(s) will be discussed in the following paragraphs.

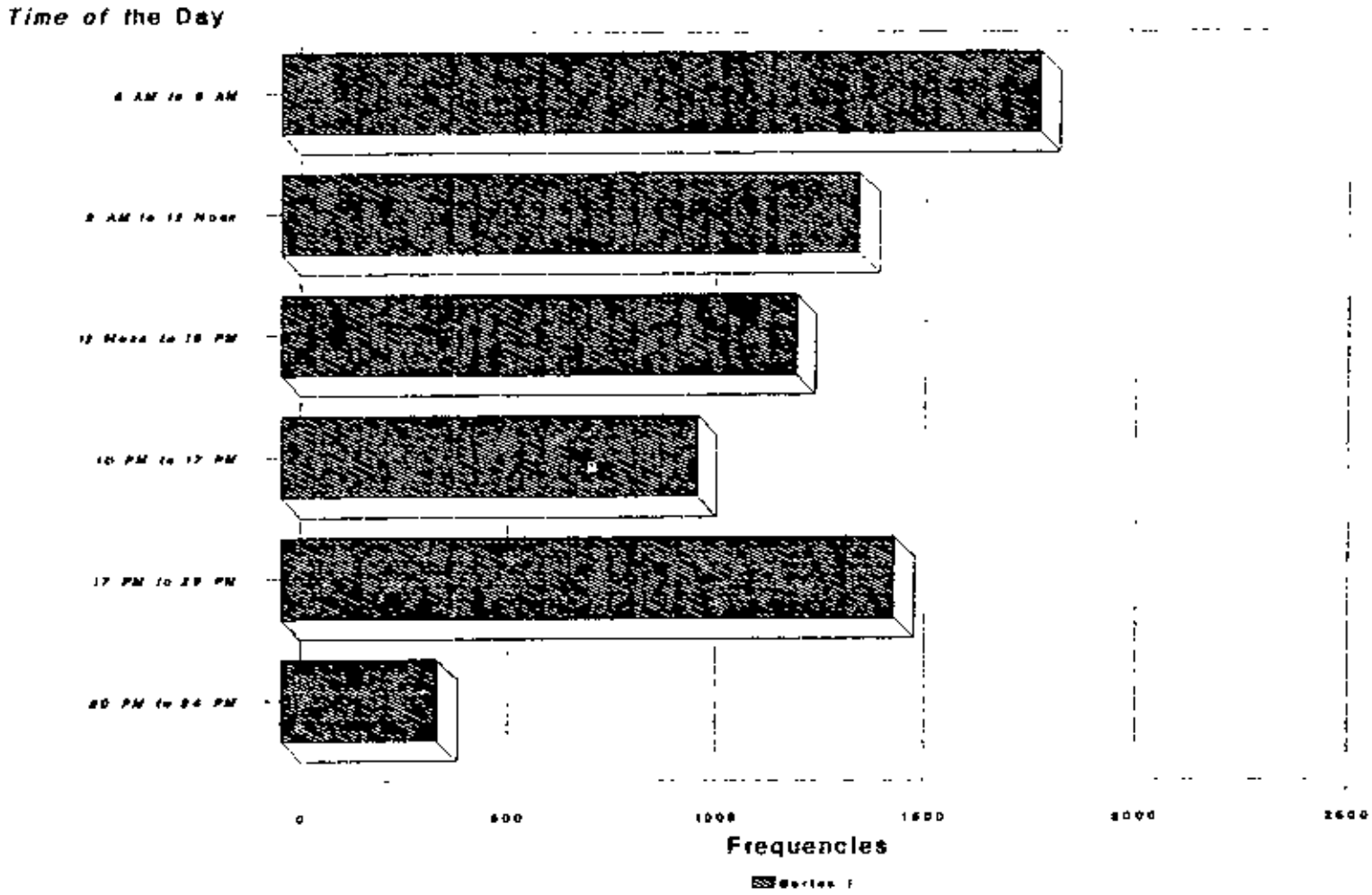
Table-5.4:
Time of the Day

Category Level	Frequency (f)	Percent of Responses
5.00 AM to 9.00 AM	1817	24.87
9.01 AM to 12.00 Noon	1390	19.00
12.01 Noon to 15.00 PM	1240	16.97
15.01 PM to 17.00 PM	1003	13.73
17.01 PM to 20.00 PM	1478	20.23
20.01 PM to 24.00 PM	380	5.20
Total	7308	100.00

Source: Field Survey December, 1989.

Figure-5.6

Time of the Day



Source: Field Survey December, 1989.

5.10 Journey Time

Journey time i.e. time required to travel is another variable that influence the travel behaviour. At present the average trip time in Dhaka City is about 20 minutes which was very low as compared with the travel time of other metropolitan cities of developing countries. This study revealed that 56 percent of all trips were required to finish within maximum 15 minutes. Table-5.5 presents the variation of trip frequencies with journey time.

Table-5.5:

Total Journey Time

Category Level (in min.)	Frequency (f)	Percent of Responses
Up to 15	4088	55.94
16 to 30	2130	29.17
31 to 45	668	9.15
45 to 60	218	2.98
61 and HI	204	2.79
Total	7308	100.00

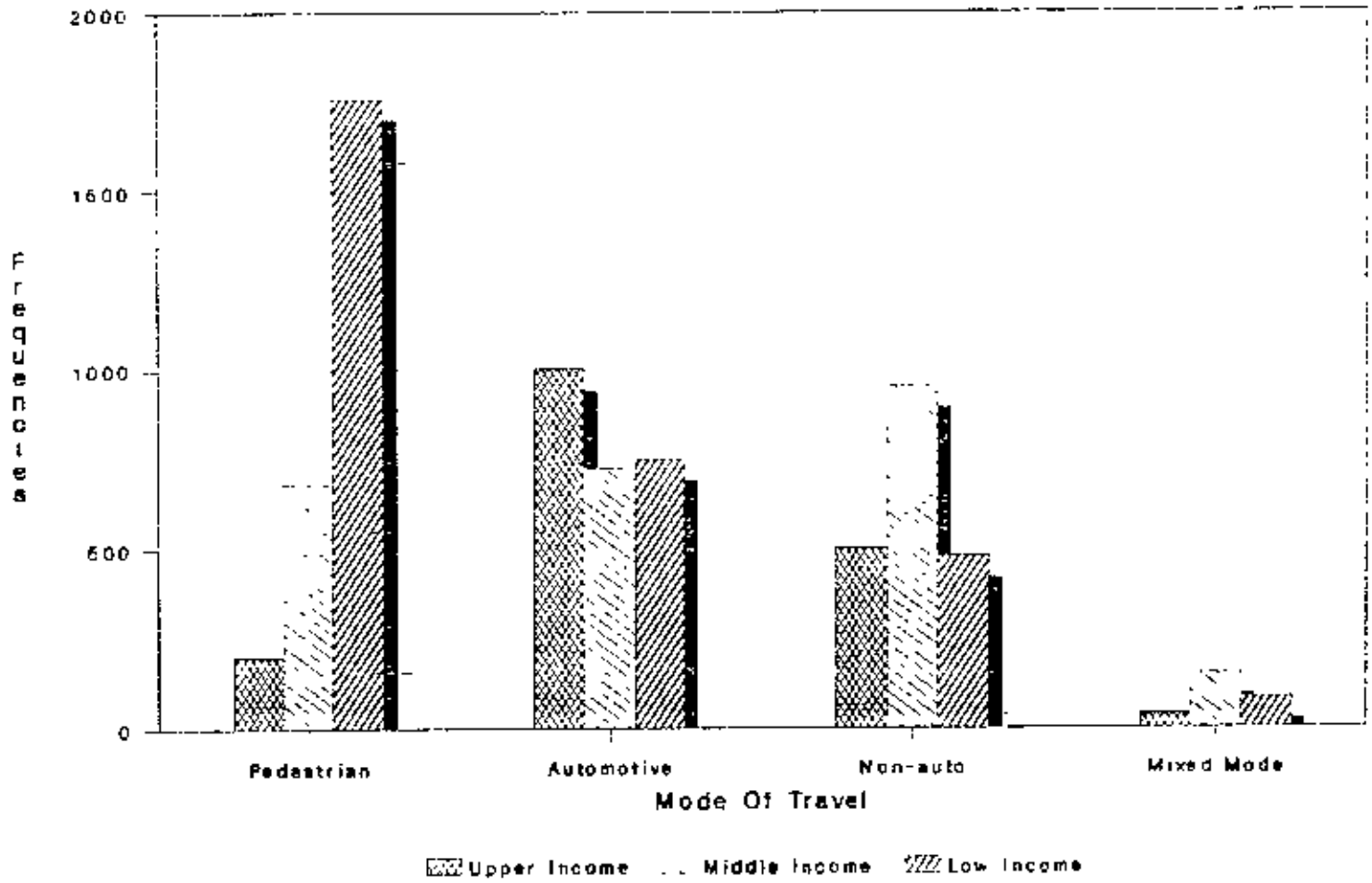
Source: Field Survey December, 1989.

5.11 Relationship between Household Income and Mode of Travel

Household income is one of the most important indicators of socio-economic position of the household. It normally controls overall behavioural characteristics of the family which in turn is reflected in travel pattern. It is usual and a common practice in all urban areas for upper income groups to spend more on transport with a tendency towards the use of comfortable and convenient modes of travel. They were time and comfort conscious rather than cost conscious. A middle income family is also comfort conscious. Low income families are normally cost conscious rather than time and comfort conscious except for special or urgent cases. They do not bother time required or inconvenience for a cheaper mode of travel. Figure-5.7 presents the influence of household income on mode use pattern. From the Table-

Figure-5.7:

Influence Of Household Income On Mode Use Pattern



Source Field Survey, December 1989

5.6 it can be seen easily that low income people use the cheapest mode of travel such as tempo and bus or walk rather than use more comfortable modes. About 57 percent of all trips made by the low income people was by walking. Middle income groups use comfortable mode of travel such as rickshaw (38 percent). Use of other comfortable automotives (motorized vehicles) such as auto-rickshaw, motor cycle were greater than the low income people. Most of the executives, professionals and managerial personnale.

Table-5.6:

Distribution of Mode of Travel by Household Income

Mode / HH Income (Taka)	Bus/ Mini-bus	Charter Bus	Car/ Jeep	Auto Rickshaw /Mishuk	Tempo	Motor Cycle/Bi-Cycle	Rick-shaw	Walk	Mixed Mode	Total
Low	322 11.0%	87 3.0%	10 0.3%	6 0.2%	210 7.0%	58 2.0%	435 14.0%	1761 57.0%	159 5.5%	3056 100.0%
Middle	276 11.0%	118 5.0%	88 4.0%	51 2.0%	82 3.0%	84 3.0%	916 37.0%	681 27.0%	210 8.0%	2505 100.0%
Upper	75 4.0%	39 2.0%	788 45.0 %	36 2.0%	14 1.0%	45 2.0%	491 28.0%	187 11.0%	82 4.0%	1737 100.0%
Total	673	252	887	93	306	185	1842	2439	451	269

Source: Field Survey December, 1989.

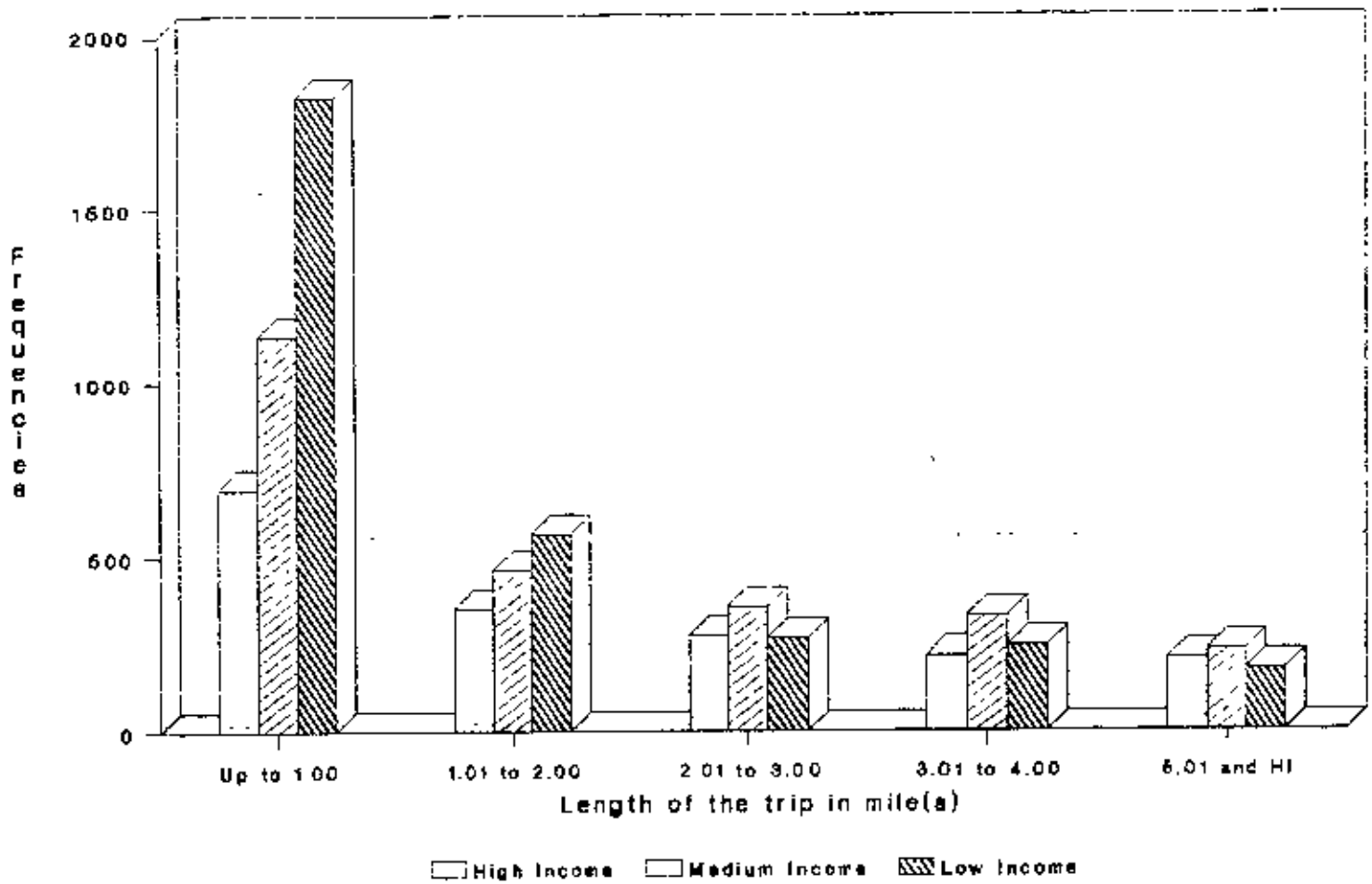
fell into this group, because of the reason that they enjoy office automotives (car/jeep, motorcycle, micro-bus). Ownership of car is related to level of household income per month so the upper income group -- the car owning (usually) group use comfortable automotives. They normally use car/jeep as the mode of travel. Use of uncomfortable cheapest mode was quite insignificant compared to the low income group.

5.12 Household Income and Trip Length

There exists a significant relationship between monthly household income and trip length. Figure-5.8 shows the variation of trip length frequencies with respect to household income. It depicts how household income affects trip length. From Table-A14 it can be seen that the low income group is the most cost conscious group. About 60 percent of all trips made by the low income groups was less than one

Figure-5.8

Trip Length Frequencies By Monthly Household Income



Source: Field Survey, December 1989.

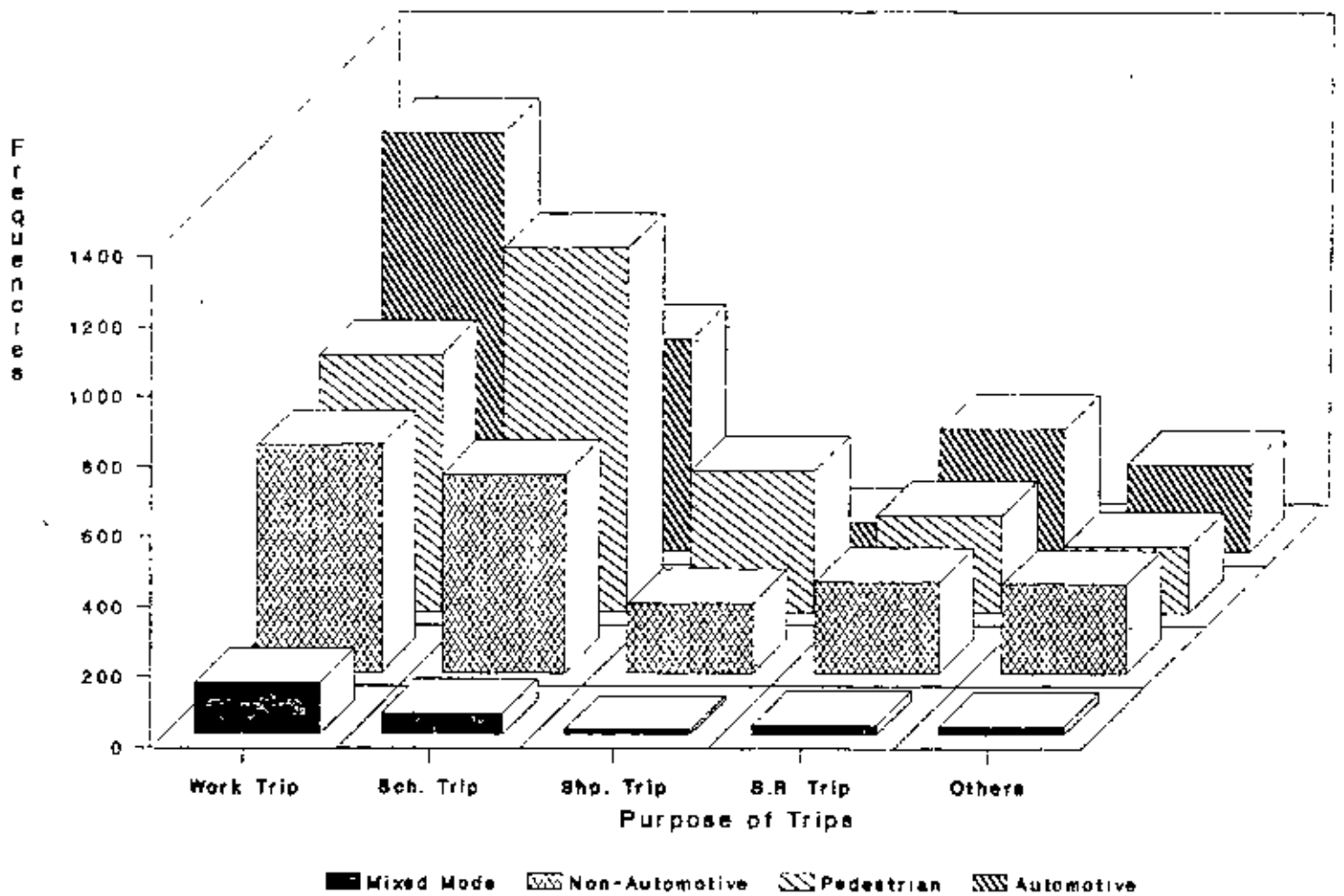
mile and only 5.7 percent of all trips were made by this group was above five miles. On the other hand about 12 percent of all trips made by the upper income group is above five miles. The test statistics also disclosed that a systematic relationship exists between household income and trip length at almost 99.90 percent confidence level. The co-efficient of correlation between household income and trip length is 0.623 and positive. This also indicates that a linear relationship exist between these two variables. It shows that as household income increases, frequencies of larger trip length increases.

5.13 Trip Purpose and Mode Choice Pattern

Making a trip is always undesirable except for recreational purpose. People make trips for different purposes. Normally they have to use a particular mode to perform a trip. For this very fact a significant relationship should exist between the mode of travel and the purpose of trip. Figure-5.9 shows the distribution of trip purposes with respect to mode of travel (automotive, non-automotive, pedestrian and mixed mode). It was stated earlier that walking is the most popular mode of travel in Dhaka City. Use of walk is the highest irrespective of trip purposes. From Table-5.7 it can be observed that in Dhaka City most of the school trips were made on foot. About 46 percent of school trips were made on foot, whereas the use of rickshaw, bus and car were 25, 12 and 8.5 percent respectively. Household having private transport usually use that for their school going children. In case of work trips, use of other modes of travel such as bus, rickshaw, car, tempo, motor bike is significant. Use of mixed mode for work trips was the highest. For shopping trips, walking and the use of rickshaw constituted 58 percent and 28 percent respectively of all trips, use of other modes for shopping purpose are mostly insignificant Use of car is the highest for socio-recreational trips. About 30 percent of socio-recreational trips were made on foot. Rickshaw accounts for about 28 percent. About 20 percent to this type of trips were made by car. This fact reveals that car owning households perform more socio-recreational trips than household with no cars. Use of other modes of travel for socio-recreational purposes were not significant.

Figure-5.9:

Trip Purposes w.r.t. Mode of Travel



Source: Field Survey, December 1989.

Table-5.7:

Distribution of Trip Purposes by Mode of Travel

Mode / Trip Purpose	Bus/ Mini-bus	Char-ter Bus	Car/ Jeep	Auto-Rickshaw /Mishuk	Tempo	Motor Cycle/ Bi-Cycle	Rick-shaw	Walk	Mixed Mode	Total
Work Trip	326 12.0%	140 5.0%	398 14.6%	23 1.0%	183 6.0%	128 5.0%	590 21.5%	734 27.0%	221 8.0%	2723 100.0%
School Trip	169 7.4%	112 5.0%	193 8.0%	6 -	77 3.4%	17 -	557 25.0%	1038 46.0%	98 4.2%	2268 100.0%
Shopping Trip	37 6.0%	0 -	14 2.8%	4 -	22 3.4%	6 -	197 28.0%	404 58.0%	14 2.0%	697 100.0%
Socio-Recre Trip	68 8.0%	0 -	192 20.0%	28 3.0%	28 3.0%	18 2.0%	251 28.0%	276 30.0%	58 6.0%	909 100.0%
Others	73 10.0%	0 -	99 14.0%	32 5.0%	16 2.0%	16 2.0%	247 35.0%	198 28.0%	40 6.0%	713 100.0%
Total	673 9.5%	252 3.6%	887 12.0%	93 1.5%	306 4.0%	185 2.5%	1842 25.0%	2639 36.0%	431 6.0%	7306 100.0%

Source: Field Survey December, 1989.

5.14 Relationship of Mode of Travel and Trip Length

The relationship between trip length and mode of travel (Table-5.8) includes the following highlights:

Use of both non-automotive transport (rickshaw and bi-cycle) and walking decreases with increasing length of trip. The frequencies of trips made on foot (walk) was almost zero when length of trip was greater than 3 miles. On the other hand use of mixed mode such as bus and tempo, tempo and rickshaw, bus and rickshaw increases with increasing length of trip. Use of automotives were nearly same whatever may be the length of trips. Looking at the test statistics and analysing them it was observed that both were highly associated at almost 100 percent confidence level.

Table-5.8:

Distribution of Trip Length By Mode of Travel

Mode / Trip Length (mile)	Automotive	Non-Auto-motive	Pedestrian	Mixed Mode	Total
0.00 to 1.00	403 11.0%	863 24.0%	2376 65.0%	8 -	3650 100.0 %
1.01 to 2.00	580 42.0%	528 38.0%	236 17.0%	31 3.0%	1375 100.0 %
2.01 to 3.00	485 54.0%	323 36.0%	23 3.0%	60 7.0%	891 100.0 %
3.01 to 5.00	520 66.0%	179 23.0%	4 1.0%	82 10.0%	785 100.0 %
5.01 to and HI	485 80.0%	34 6.0%	0	88 14.0%	607 100.0 %
Total	2473 34.0%	1927 26.0%	2639 36.0%	269 4.0%	7308 100.0 %

Source: Field Survey December, 1989.

5.15 Relationship between Trip Purpose and Time of the Day

People perform different activities for different purposes throughout the day. But frequency distribution of trip-making is not same for a particular purpose throughout the day. From Table-5.9 it can be observed that most of the morning (5 A.M. to 9 A.M.) trips were the essential trips i.e. work trips, school trips and shopping trips. Frequency of socio-recreational and shopping trips were the highest during the evening period (5 P.M. to 8 P.M.). Most of the people go out for work purposes in the morning and return in the evening. That was due to the fact of changing behavioral pattern of tripmaking in Dhaka City. Trip making frequency for work was greater in the morning and in the evening. There was a remarkable percentage of category of undefined trip purposes termed as 'others' which was evenly

distributed throughout the day. Statistically, they are positively correlated and the interdependence between the two variables was significant at 99.97 percent confidence level.

Table-5.9:

Trip Purposes by time of the Day

Purpose of trip / Time (hrs.)	Work trip	School trip	Shopping trip	Socio-Recrea-tional trip	Others	Total
5.00 to 9.00	863	617	173	54	110	1817
9.01 to 12.00	333	718	113	83	143	1390
12.01 to 15.00	499	477	64	57	141	1240
15.01 to 17.00	241	361	79	199	123	1003
17.01 to 20.00	542	87	260	424	165	1478
20.01 to 24.00	247	6	8	90	31	380
Total	2723	2266	697	909	713	7308

Source: Field Survey December, 1989.

5.16 Conclusion

Household members undertaking trips are classified into two main groups -- home-based trip and non-home-based trip. This research disclosed that in Dhaka City about 93.0 percent of all trips were home-based whereas non-home-based trips were only 7.0 percent. The average number of home-based trips per household per day i.e. trip rate is 9.43, ranging from no trips to 28 trips per household per day. The average number of trips increases with increasing persons household, at a rate of approximately 1.62 trips per day for each additional person and this increase tends to level-off at six persons per dwelling unit family size.

The number and frequency of trips generated from home increases with increasing

family income, 52 percent of low income people generate only 4200 percent of all trips made by the tripmakers whereas 32.0 percent of middle income group and 16.0 percent upper income group generated 34.0 percent, 24.0 percent of all trips respectively. Trip rates of these three groups were 7.74, 9.94 and 13.68 respectively. Usually it is expected that increase in distance from City Centre leads to increased trips per household per day (Martin, 1962). But in case of Dhaka City trips per household per day decreases with the increase in distance from City Centre.

Among the different mode of travel available in Dhaka City, rickshaw is the most popular and easily available mode of travel. Though personal motorized vehicle ownership with continue to rise, still walking and rickshaw were the major modes of travel in Dhaka City. About 36.0 percent of all trips were made on foot, while only 25.0 percent of all trips were made by rickshaw.

In Dhaka City, tripmaking frequency was highest for work purposes. About 37.0 percent of all trips undertaken by the individual households were work trip while school trips, shopping trips, socio-recreational trips and others were 31.0, 9.54, 12.44 and 9.76 percent respectively. Trip frequencies decrease with the increase in trip length. About 50.0 percent of all trips made by the tripmakers were less than one mile. They try to reside close to their necessary destination.

Now-a-days traffic congestion is a regular phenomenon in Dhaka City. Traffic congestion and the associated problems of limited roadway capacity and travel delays occurred during the peack periods of the day, most noticeably in the evening hours of 5 P.M. to 8 P.M. and second short-term peak occurred in the morning hours between 8 A.M. to 10 A.M.

Upper income peoples were time and confort conscious rather than cost conscious. On the otherhand, low income families were normally cost conscious rather than time and confort conscious except for special or urgent cases. They do not bother time required or inconvenience for a cheaper mode of travel. Low income people use the cheapest mode of travel such as walk, bus or tempo. About 57.0 percent of all trips made by the low income people was by walking with shorter haul,

whereas upper income group made 11.0 percent trips by walking. Middle income group mainly depend on rickshaw. About 37.0 percent of all trips were made by Rickshaw. Upper income group -- the car owning group mainly use cars and 46.0 percent trips were made by cars with longer haul.

It was observed that most of the school trips were made on foot, about 46 0 percent of school trips were made on foot, whereas use of rickshaw, bus and car were 25.0, 12.0 and 8.5 percent respectively. In case of work trip use of bus, rickshaw, car, tempo motor bike is significant. Use of mixed for work trip was the highest. For shopping trips, walking and rickshaw constituted 58.0 and 28.0 percent respectively, use of other mode were not significant.

Trip making frequency for work was greater in the morning and in the evening. Most of the people go out for work purposes in the morning and return in the evening. This was due to the fact of changing behavioural pattern of tripmaking in Dhaka City.

CHAPTER VI

CHAPTER SIX

MODEL CALIBRATION

6.1 Introduction

Transport studies attempt to describe and to predict the travel demand accurately using a series of linked sub-models and trip generation stage is intended to prepare forecasts of travel demand by a geographical unit. This forecasting process involves the development of models. Trip generation models employ the concept of regression analysis. Multiple linear regression models were calibrated to develop the required models. It is the statistical technique where two or more independent variables were assumed of simultaniously affecting the amount of travel.

All the variables assumed initially cannot be treated as independent variables for regression analysis. Because some of the variables may not have any relationship at all with the dependent variable (home-based trips per household per day i.e. trip rate) and some of the independent variables may be represented by other independent variables i.e. they may not unique.

In order to perform regression analysis, it is essential to have knowledge about association between the dependent variable and independent variable(s). To find out the relationship between the variable(s), measure of correlation and measure of association were used. For quantitative variable(s) the selection criteria can be fulfilled simply by correlation coefficient. Variable(s) having higher and significant correlation either positive or negative with the dependent variable was/were selected as independent variable(s). In order to select qualitative variable(s) chi-square test statistics was used. Applying the chi-square test statistics the association between dependent variable and all the other independent (qualitative) variable(s) were measured, the variable(s) having significant association with the dependent variable at 0.001% level of significance were selected as independent variable(s).

After primary selection of independent variables on the basis of correlation and chi-square test statistics independent variables were further investigated to detect inter relationship among them.

6.1.1 Measure of Correlation

In this section, correlation co-efficient between the dependent variable (home-based trips per household per day) and independent variables and also between independent variable(s) themselves were tested. All the information regarding correlation among different variables including dependent and independent were given in the Table 6.1. From Table 6.1 it can be seen that total journey time (TJT) had the highest positive correlation (0.6603) with the dependent variable -- Home-based Trips per Household per Day (TPH) which was highly significant ($P<0.000$). The independent variable trip length (TL) had the next highest positive correlation (0.613) with TPH. That was also highly significant ($P<0.000$). The coefficient of correlation of family size (FS), number of vehicle(s) owned (NVO), monthly household income (INC), employees per household (EMP) are 0.437 ($P<.000$), 0.411 ($P<0.000$), 0.600 ($P<0.000$) and 0.216 ($P<0.000$) respectively.

Thus it can be said that the independent variables TJT, TL, FS, NVO, INC, EMP have significant correlation with the dependent variable TPH.

All the aforesaid variables having significant relationship with TPH cannot be used as independent variables. As some of them are highly correlated and dependent with each other, which is termed as multicollinearity.

The practical interpretation of multicollinearity is that two or more correlated variables are explaining largely the same effect and may, therefore, be considered substitute causes.

There is no generally accepted rules for deciding when multicollinearity is severe enough to require action, or for deciding what action to take (Douglas, 1974). It is sometimes argued that if the correlation between two individual variable exceeds their individual correlations with the

Table-6.1:

Co-efficient of Correlation of Selected Variables

Variable	TPH	FS	INC	TL	MOT	POT	NVO	TJT	EMP
TPH	1.000	0.437	0.600	0.813	0.159	0.338	0.411	0.660	0.261
FS	0.437	1.000	0.278	0.316	0.131	0.237	0.202	0.416	0.392
INC	0.600	0.278	1.000	0.577	-0.285	0.093	0.458	0.623	0.313
TL	0.813	0.316	0.577	1.000	-.0274	0.156	0.408	0.847	0.280
MOT	0.159	0.131	-0.295	-0.275	1.000	0.216	-0.221	0.247	0.193
POT	0.338	0.237	0.093	0.156	0.216	1.000	0.114	-0.098	0.201
NVO	0.411	0.202	0.458	0.407	-0.220	0.114	1.000	0.536	0.142
TJT	0.660	0.416	0.623	0.847	0.246	0.098	0.536	1.000	-0.273
EMP	0.261	0.392	0.313	0.280	0.193	0.201	0.142	-0.273	1.000

dependent variable then one of the independent variables should be omitted from consideration. If one of the variables is preferred, perhaps because it is easier to forecast or in more meaningful then that one could be included. In any case, if two variables are highly correlated it is most unlikely that both variables would be selected for inclusion by regressions method. Some indication of the effect of multicollinearity can be obtained by examining changes in the regression coefficients at each step of built-up procedure. Large changes in magnitude or sign indicates an unstable relationship (Douglas, 1974).

From the Table-6.1 it can be seen easily that the independent variable total journey time (TJT) has the highest significant correlation (0.847, $P<0.000$) with trip length (TL).

The independent variable TJT i.e. time required to complete a trip mainly depends on trip length. Besides many other factor(s) also affect journey time such as traffic jams, waiting time, accessibility etc. and it cannot be forecasted due to the above implied factors.

Consequently the individual effects of these variables on trip-making behaviour would be somewhat obscure if both were included in regression equation. The variable TJT has also highly significant correlation with size of the family, monthly household income, vehicle(s) ownership and employee(s) per household.

Therefore it can be discarded though it has the highest correlation with the dependent variable and highly significant while comparing with the other independent variables. Although the independent variable trip length (TL) was highly correlated with the dependent variable it should also be discarded because it cannot be forecasted.

Again from the Table-6.1 the coefficient of correlation of employee(s) per household with the dependent variable is 0.261, which is also highly significant ($P<0.000$). It has also highly significant correlation (0.392, $P<0.000$) with the family size (FS). This indicates that two of them cannot appear together in any analysis. Although the independent variables NVO with INC, and FS with INC, NVO have highly significant correlation but all these variables were retained in the model, as all of them have independent effect on dependent variable Home-based Trips per Household per Day.

6.1.2 Measure of Association

In order to select qualitative variables Chi-square test statistics were used. Applying these chi-square test statistics the association between the dependent variable and the qualitative variable(s) were measured. The variable(s) having significant association with the dependent variable at 99.99% confidence level were selected as independent variable(s).

From the Table-A15 it can be seen easily that the association of independent variables purpose of trip (POT) and mode of travel (MOT) with dependent variable were highly significant at a confidence level of 99.999% with a contingency coefficient of 0.76. These behavioural test statistics indicated that they might be included in the regression analysis, but these two variables should also be discarded as they cannot be forecasted for estimation of future trip generation.

Finally it can be concluded that out of eight independent variables three variables can be considered as independent variables for this analysis. The selected variables were Size of the Family (FS), Monthly Household Income (INC), Number of Vehicles Owned per Household (NVO).

6.2 Model Calibration

Regression analysis was performed on the data obtained from the field survey in order to find out home-based trip generation model for Dhaka City. Independent variables for the model were selected after satisfying the selection criteria (measure of correlation and measure of association, investigation of multicollinearity) described earlier in this chapter.

Proper testing and examination of the regression models were made before the acceptance as forecasting tools. Only one set of independent variables was used to develop anticipated models.

The Model : The Model contains the following three independent variables. These are monthly household income (INC), size of the family (FS) and number of vehicle(s) owned per household (NVO).

6.3 Results of the Model

In this section three sets of independent variables were used to find out the significant variables for the model with TPH as the dependent variable.

Model : Home-based Trips per Household per Day (TPH) is the dependent variable.

Results of the model :

The following Table gives the results of the model with the three independent variables. The total number of cases is 775.

Table-6.2:

Stepwise Regression procedure applied to home interview data for Home-based Trip generation Modelling for Dhaka City

Stepwise Equation Number	Equation	Correlation Coefficient (R)	$100xR^2$
1.	Trip Rate = 0.00065* (Household Income) + 3.91	0.538	28.90
2.	Trip Rate = 0.00056* (Household Income) + 0.393* (Family Size) + 1.638	0.641	41.08
3.	Trip Rate = 0.00051* (Household Income) + 0.380* (Family Size) + 0.380* (Vehicles Owned per Household) + 1.34	0.647	41.90

Table-6.3:

Regression Estimates of Coefficients of the Model and Related Statistics

Vari-ables	Estimated coefficients (B)	Standard Error of B	t-Value	Significance of t
INC	0.00051	$3.98x10^{-5}$	13.025	0.0000
FS	0.380	0.031	12.197	0.0000
NVO	0.307	0.092	3.318	0.0009
Constant	1.705	0.193	8.827	0.0000

Although Equation 3 (Table-6.2) has passed all the various statistical tests at a significance level of 0.000 percent. But inclusion of vehicles owned per household (NVO) in the model was not very much significant. Only 0.80 percent variation of the dependent variable could be explained by NVO. For this reason finally Equation-Two was considered. The multiple correlation coefficient (R) indicates the degree of association between the independent variables and the dependent variable. A

multiple correlation of 0.641 indicated that approximately two-fifth (or 41%) of the variation of the dependent variable TPH was explained by the independent variables included in the equation. The constant in the equation was the affect of excluded variables. The magnitudes of the t-values indicated the relative importance of each of the variables in the equation. Independent variables which have a t-value of less than 2.0 do not have a significant relationship with the dependent variable and therefore, contribute nothing to the equation. Any such independent variables should be deleted from the equation (Norman, 1987). It can be seen that household trip making frequency increases as size of the family, household income and car ownership per household increases together or individually.

In order to predict the Home-based Trips per Household per Day, the final prediction equation:

$$T = 0.00056 \times INC + 0.393 \times FS + 1.638$$

where, T = Home-based Trips per Household per Day

INC = Monthly Household Income

FS = Size of the Family

With this prediction equation, dependent variable home-based trips per household per day can be computed for any given combination of the independent variable(s) entered into the equation assuming that regression coefficients established today will hold good for any future date. However it must be recognised that human behaviour is not completely rational, and that the very wide variation in tripmaking activity can probably never be fully explained by any model.

Total trips generated by a zone or an areal unit can be easily obtained by multiplying the value of T (home-based trips per household per day) by the number of households in that zone or areal unit.

6.4 Limitation of the Model

The present models, like their earlier counterparts were also based on more or less insufficient data. Lack of information, insufficient information, inaccurate/biased information, crude assumption very often play crucial role to whole exercise.

As a consequence, performance of the models in the real situation has not always been reasonably satisfactory, which in turn has led to dissatisfaction with modelling in general.

Information content, especially related to household income often turns out to be biased and inaccurate. The most common reasons are lack of sufficient knowledge and individual difference in perception about the research work. Some of the variables have been derived based on crude assumptions. But quality of data is very important of trip generation modelling process.

6.5 Category Analysis

Category analysis was one of the most popular forecasting tools to estimate zonal trip generation, which was developed in Britain by Wooton and Pick (1967). One of the objectives of this study was to tally the results obtained with the regression models. In this section zonal trip generation was estimated by using different steps of category analysis.

The technique was based on determining the average values or average responses of the dependent variable for defined categories of the independent variables. The categories are defined by a multi-dimensional matrix where each dimension represents an independent variable and where the independent variables were themselves stratified into a number of categories. In its application to the trip generation each observed analysis unit (e.g. household level) is assigned to a particular category or cell of the matrix depending on its values of the independent variables (typically such measures as family size, household income, number of cars per household etc.) and average trip rates are subsequently determined for each cell (Douglas, 1974).

Mean trip generation rate for each category was calculated from the survey data. In using the category analysis as a forecasting tool it is assumed that the trip rates associated with each household category will remain stable over time and zonal traffic can then be estimated by simply multiplying the mean trip rates for each category by the number of household in that category for each zone and then

summing all the categories in the zone.

In this study households were classified in terms of two variables, family size (persons per household) and household income -- eight categories (from 2 member family to 9 member family) of family sizes and three categories (low income, middle income and upper income) of household income were specified.

Table-6.4:

Household Income by Family size and corresponding Trip Rates

FS / INC	2	3	4	5	6	7	8	9	Total
Upto Tk 5000	16 3.812	24 4.833	76 6 276	84 7.214	75 8.133	51 8.333	45 9.067	26 10 20	396 7 234
Tk 5001 to 25000	4 5.500	11 4 910	23 8 000	48 9.896	50 10.480	35 10.230	21 11.333	60 11.683	252 8.99
25001 and Above			3 10 667	37 13.054	27 14 185	20 14.450	18 15.444	22 14.640	127 13.74
Total	20 4.660	35 4.870	102 8.314	169 10 050	152 10.930	106 11 000	84 11.950	107 12.140	775 9.430

Source: Field Survey December, 1989.

The trip generation matrix of Table 6.4 was prepared by sorting all households interviewed in the survey into one of the 24 (8x3) cells. The number of trips produced by all households in a cell and the number of households in the cell were then summed. The trip rate for each cell was then established by dividing the number of trips by the number of households.

After establishing the average trip rate for each cell, zonal trips can be estimated (a) multiplying the average trip rate for each cell or category by the number of households in each category those were located in the zone and (b) summing the amount of traffic for every household category.

$$Q_{pi} = \sum_{i=1}^{n} Q_c . N_{ci}$$

Where,

Q_{pi} = estimate of the zonal number of trips produced by zone i

Q_c = average trip rate for category c type household and

N_{ci} = number of category c type households located in zone i

6.6 Comparison and Conclusion

From Table-6.4, the average number of home-based trips per household per day was 9.43. In order to compare the models with category analysis, considering the study area as a hypothetical Traffic Zone. Hence total number of household of that zone was 775 and average household income per month and average family size were about Tk. 9270 and 6.07 respectively.

Using the model :

$$T = 0.00056 \times INC + 0.393 \times FS + 1.638$$
$$= 0.00056 \times 9270 + 0.393 \times 6.07 + 1.638$$
$$= 9.215$$

Hence average number of home-based trips per household per day of this zone was 9.215. Now total number of home-based trips generated by a traffic zone/district can easily be calculated by multiplying total number of households of that zone/district with the trip rate obtained by the model.

In category analysis only two variables -- monthly household income and family size were manipulated. But in case of model development a number of variables were considered. Although finally only two variables were retained in the equation but the constant represent the net impact of all excluded variables those were initially considered as responsive variables in trip making frequency.

CHAPTER VII

CHAPTER SEVEN

SUMMARY AND CONCLUSION

7.1 The Summary

The purposes of this research were to study the travel behaviour of Dhaka population and to offer a preliminary framework for trip generation analysis - the main concern was to develop Home-based Trip Generation Models for Dhaka City. A trip (both home-based and non-home-based) is a purposeful journey by any transport mode (including walking) from one place to another usually covering a distance of a street block or more. Travel data was collected from individual household level.

While comparing with the other large metropolitan cities, it was found that the percentage of home-based trips was greater in case of Dhaka City. This study revealed that about 93 percent of all trips were home-based in Dhaka City and the rest i.e. about 7 percent trips were non-home-based.

With the recent increase in economic actitivies, the number of trips (trip rate) of urban dwellers increased compared to the trip rates of the dwellers some years before. This research indicated that the trip rates i.e. average number of home-based trips per household per day was 9.43, as compared with the trip rate (6.89) in 1983, ranging from no trips to 28 trips per household per day.

Cross classification technique was used in selecting the sample areal units considering the socio-economic status (upper, middle and low income groups) and distance from the City Centre (long, medium and short distances). Both the above factors have remarkable influence on trip generation i.e. on trip rates. The number of home-based trips per household per day has increased as monthly household income increased. Upper income group made more trips than the middle income and low income group. As locational distance of the residential areal unit increased, the trip rates i.e. the number of home-based trips per household per day decreased.

This research disclosed that the average number of trips per household per day increased with the increase in person(s) per household at a rate or approximately 1.62 trips per day for each additional person. This increase in number of home-based trips per household per day with the family size tended to level-off at about six persons per dwelling unit family size.

Although personal motorized vehicle ownership and rate of motorization increased in the recent years, walking and rickshaw were still the main modes of travel in Dhaka City. With the increase in economic activities, most of the large organizations (both private and government) have their own transport to bring their staff. This study revealed that about 5 percent of all trips made by charter bus (which was known as staff-bus in Dhaka City).

Dhaka suffers from road way congestion during the peak-use periods like other major metropolitan areas, traffic congestion is a regular phenomenon in Dhaka City. Traffic congestion and associated problems of limited road way capacity and travel delays occur during the peak periods of the day, most noticeably in the evening hours of 5 p.m. to 8 p.m. The second and often very pronounced short-term peak occurrs in the morning hours between 8 a.m. to 10 a.m. Traffic congestion on some roads of Dhaka City are regular phenomena in the evening hours of 5 p.m. to 8 p.m. This is one of the remarkable changing travel behavioural pattern of the urban dwellers This very fact indicated that economic activity i.e. movement of urban dwellers increased in the recent years almost in all the urban centre as well as in Dhaka City.

One of the main objectives of the study was to find out the trip generation models to predict the home-based trips per household per day generated by a geographical unit. Stepwise regression method was used to find out the best possible regression models. Independent variables were selected on the basis of the relationship they have with dependent variable as well as with themselves. In selecting the relationship, measure of correlation and measure of association were used. Out of eight variables three variables were finally selected for regression analysis. These were monthly household income (INC), size of the family (FS), number of vehicles owned per household (NVO).

Independent variables were primarily selected on the basis of correlation and association. Then whether multi-collinearity exist or not between the variables were tested. Qualitative variables were incorporated in regression analysis after regrouping them. Proper statistical testing and examination of the regression model was made before its acceptance as a forecasting tool.

Category analysis is another forecasting tool to estimate zonal trip generation, which was developed in Britain by Wooton and Pick (1967). In its application to trip generation each household were classified in terms of two variables -- family size (persons per household) and household income. Eight categories (from 2 member family to 9 member family) of family sizes and three categories (low income, middle income and upper income) of household income were specified. The trip generation matrix was prepared and average trip rate for each cell was calculated. After establishing the average trip rate for each cell, zonal trips can be estimated easily by (a) multiplying the average trip rate for each cell or category by the number of households in that category those were located in the zone and (b) summing the amount of traffic for every household category.

7.2 Recommendation

The mass transport system and service of Dhaka City does not possess enough significant role for catering to the need of the people. Most of the residential areas are separated from the main routes of the mass transit. As a consequence 'rickshaw' & 'walking' have been proved to be the most essential mode of transport. So the need of a functional and effective mass transit system should be considered.

Every efforts should be made to develop all the districts and communities of the City with a properly recommended access standard so that unwanted travel demand can be avoided. This effort also may limit the recreational and shopping trips during the peak period.

Haphazard arrangement of land use creates the problem by increasing the volume of cross-hauling among the functions those have been separated geographically

which actually should have been co-existent. Development and evaluation of integrated land-use and transportation planning can minimize the rate of trip generation.

Possibilities of applying some of improved technological changes i.e. transport planning through non-transport mode like -- improved telecommunication system, mechanized method of material handling, home deliveries, mail order shopping etc., may have a remarkable influence on reducing the need for unwanted trips.

An effective way of bringing down peak hour transport demand is to distribute traffic load over more time periods through staggering the working hours. Thus peak hour traffic load can be optimized. Recent change in Government and Semi-Government Office time have already reduced traffic jams during the peak hour period.

Trip generation is a function of family size. To limit the trip number -- special endeavour should be given to design integrated policies associated with the national family planning objectives.

Finally there is a clear need for an integrated authority to have a sound development of different transportation facilities and land-use patterns which should be evaluated in terms of the communities long range development objectives.

7.3 The Conclusion

Trip generation modelling has great significance in the conventional transportation planning process. The present experience of trip generation modelling reminded the real world difficulties that the model builders have to face. With the prediction equation, the model already developed, dependent variable home-based trip per household per day can be easily computed for any given combination of independent variable(s) entered into the equation assuming that regression coefficients established today will hold good for any future day say for after 10 years or 20 years. Total trips generated by a areal unit or by a traffic zone can

easily be obtained by multiplying the value of Trip Rate (home-based trips per household per day).

The crucial assumptions made was regression coefficients established today will hold good for any future date. But changes in the landuse and socio-economic characteristics could result in a different relationship between the independent variables expressed in terms of completely different regressions coefficients.

In case of category analysis, which based its predictions on the assumption that the generation rates exhibited today by different classes of household will hold good in the future, avoids these criticisms but absence of any facility for testing the statistical significance of the variables to explain the tripmaking behaviour is a serious deficiency in the technique.

The derived trip generatio model can be used in predicting future trips generated by a areal unit.

The transport study process comprised a number of inter-related models which enable future travel conditions to be predicted. The process -- basically trip generation, trip distribution, modal split and assignment, are applied initially to the base-year planning data in order to predict synthesized movements for comparison with observed movements. Once the models are adjusted to predict present-day conditions, they can be used in predictive mode to ascertain likely design-year travel movements. Trip generation modelling process is the first step in the four step modelling process n transport planning. Further research works can be taken for the rest three steps.

In transportation planning process this trip generation model, one of the four step model in transport study, can be used as a planning tool to determine the persons trips generated by a traffic zone or leaving a traffic zone.

APPENDIX-A

Table-A1:

Summary Statistics of some Variables

Variables	Average value	Standard Deviation	Minimum	Maximum
Family Size	6.065	1.832	2	9
Person Employed	1.563	0.830	0	6
Number of Vehicles Owned	0.299	0.650	0	4
Number of Trips of Tripmaker-I	3.215	1.492	0	6
Tripmaker-II	2.441	1.217	0	6
Tripmaker-III	1.973	1.434	0	6
Tripmaker-IV	1.219	1.330	0	6
Tripmaker-V	0.582	1.085	0	6
Number of Trips per Household per day	9.43	4.188	0	28
Number of Trips per Person per day	1.618	0.686	0	5
Student	1.58	0.910	0	7

Source : Field Survey December, 1989.

Table-A2:

Education Level of the Head of the Household

Category Level	Frequency (f)	Percent of Responses
Primary	119	15.4
Secondary	194	25.0
Higher Secondary	130	16.8
Graduation	278	35.9
Illiterate	51	6.6
Missing Values	3	0.4
Total	775	100.0

Source : Field Survey December 1989.

Table-A3:

Occupation of the Head of the Household

Category Level	Frequency (f)	Percent of Responses
Professional	72	9.3
Administration and Managerial	80	10.3
Student	0	0.00
Housewife	15	1.9
Clerical and Related	173	22.3
Self Employed	234	30.2
Sales and Services	37	4.8
Manufacturing and General Workers	63	8.1
Others	98	12.6
Missing Values	3	0.4
Total	775	100.0

Source : Field Survey December, 1989.

Table-A4:

Income Level of the Urban Dwellers

Income Category Level	Frequency (f)	Percent of Responses	Assumed Percent
Low Income Group (Up to Tk. 5000)	403	52.00	60.00
Middle Income Group (Tk. 5001 to Tk. 25000)	247	31.90	30.00
Upper Income Group (Tk. 25001 and HI)	125	16.10	10.00
Total	775	100.00	100.00

Source: Field Survey December, 1989.

Table-A5:

Ownership of the Resident

Category Level	Frequency (f)	Percent of Responses
Owned	432	55.7
Office quarter	62	8.0
Rented	252	32 5
Occupied	27	3.5
Missing/Not applicable	2	0.3
Total	775	100.0

Source: Field Survey December, 1989.

Table-A6:

Frequencies of Type of Trips

Category Level	Frequency (f)	Percent of cases
Home-Based	7308	93.11
Non-Home-based	541	6.89
Total	7849	100.00

Source: Field Survey December, 1989.

Table-A7:

Modal Choices of Urban Dwellers-1

Category Level	Frequency (f)	Percent of Responses
Bus/Mini-bus	673	9.2
Charter Bus	252	3.34
Car/Jeep	887	12.14
Auto-Rickshaw/Mishuk	93	1.27
Tempo	306	4.19
Motor-Cycle Bi-Cycle	185	2.53
Rickshaw	1843	25.20
Walk	2639	36.12
Bus+Tempo	162	2.22
Total	7308	100.00

Source: Field Survey December, 1989.

Table-A8:

Modal Choices of Urban Dwellers-2

Category Level	Frequency (f)	Percent of Responses
Automotive	2558	35.00
Non-automotive	1842	25.20
Pedestrian	2639	36.12
Mixed-Mode	269	3.68

Source: Field Survey December, 1989.

Table-A9:

Frequencies of Trip Length

Category Level (in mile)	Frequency (f)	Percent of Responses
Up to 1.00	3650	49.95
1.01 to 2.00	1375	18.81
2.01 to 3.00	891	12.20
3.01 to 5.00	785	10.74
5.01 and HI	607	8.30
Total	7308	100.00

Source: Field Survey December, 1989.

Table-A10:

Distribution of Age of the Tripmakers by Occupation

Ocpn / Age (yrs)	Profe-ssional	Admin. and Manage-rial	Student	House wife	Clerical and Related	Self Employ-ment	Sales and Services	Manufac turing + Workers	Others	Total
6 to 15	0	0	774	0	0	0	2	7	26	809
16 to 25	7	0	438	34	27	59	38	43	98	744
26 to 35	37	18	12	78	97	126	21	42	47	477
36 to 45	34	30	0	48	80	92	10	16	18	328
46 to 55	29	42	0	20	45	67	4	9	32	248
56 and HI	8	2	0	5	4	15	2	6	32	74
Total	115	92	1224	185	253	358	77	123	253	2680

Source: Field Survey December, 1989.

Table-A11:

Education Level by occupation of Tripmakers

Occpn / Edu. Level	Profe-ssional	Admin. and Manage-rial	Student	House wife	Clerical and Related	Self Employ ment	Sales and Services	Manufac-turing + Workers	Others	Total
Primary	0	0	362	38	12	65	26	58	48	610
Secondary	0	0	440	51	76	111	31	30	75	816
Higher Secondary	0	0	265	60	100	58	3	12	27	515
Graduation	115	92	157	28	62	101	8	1	33	598
Illiterate	0	0	0	16	0	23	9	22	70	141
Total	115	92	1224	185	258	358	77	123	253	2680

Source: Field Survey December, 1989.

Table-A12:

Distribution of Family Size by Number of Trips

No. of Trips / FS	2	4	6	8	10	12	14	16-28
2	6	7	6	1	0	0	0	0
3	5	13	2	2	1	1	0	0
4	5	26	25	25	18	7	1	0
5	5	15	26	39	32	24	11	17
6	3	9	17	27	49	12	10	24
7	1	8	11	27	21	13	9	16
8	2	4	8	15	14	11	16	14
9	-	2	5	11	19	27	21	22
Total	27	84	106	146	155	95	68	93
Statistics		Chi-square 406.47		D.F. 70			Significance 0.0000	
		n 7308					Contingency 0.763	

Source: Field Survey December, 1989.

Table-A13:

Distribution of mode of Travel by Household Income-2

Mode / HH Income	Automotive	Non-automotive	Pedestrian	Mixed mode	Total
Low Income	747 (24.5%)	476 (15.5%)	1761 (57.0%)	82 (3.0%)	3066 (43%)
Middle Income	724 (28.8%)	951 (38.%)	681 (27.2%)	149 (6.0%)	2505 (34%)
Upper Income	1002 (57.6%)	500 (28.7%)	197 (11.5%)	38 (2.2%)	1737 (24%)
Total	2473 (33.8%)	1927 (26.4%)	2639 (36.1%)	269 (3.7%)	7308

Source: Field Survey December, 1989.

Table-A14:

Distribution of Household Income by Trip Length

Trip Length (mile) / HH Income	Up to 1.00	1.01 to 2.00	2.01 to 3.00	3.01 to 5.00	5.01 and above	Total
Low Income <Tk.5000	1822 (59.4%)	563 (18.4%)	265 (7.9%)	243 (5.7%)	173 (5.7%)	3066
Middle Income Tk. 5001 to Tk. 25000	1134 (45.3%)	461 (18.4%)	354 (14.1%)	327 (13.0%)	229 (9.2%)	2505
High Income >Tk.25000	694 (40.0%)	351 (20.2%)	272 (156%)	215 (11.8%)	205 (11.8%)	1737
Total	3650	1375	891	785	607	7308

Source: Field Survey December, 1989.

Table-A15:

Distribution of Trip Purposes by Mode of Travel

Mode / Purpose	Automotive	Non-automovite	Pedestrian	Mixed mode	Total
Work trip	1192	650	734	147	2723
School trip	603	564	1038	61	2266
Shopping trip	81	199	404	13	697
Socio-Recreational trip	348	260	275	26	909
Others	249	254	188	22	713
Total	2473	1927	2639	269	7308

Source: Field Survey December, 1989.

Table-A16:

Distribution of Trip Purpose by Monthly Household Income

Trip / HH Purpose / Income (Tk.)	Work Trip	School Trip	Shopping Trip	Socio-Recreational Trip	Others	Total
Low Income <Tk.5000	1319 (43%)	979 (32%)	280 (9.1%)	265 (8.7%)	223 (7.2%)	3066
Middle Income Tk. 5001 to Tk. 25000	844 (34%)	827 (33%)	285 (11%)	299 (12%)	250 (10%)	2505
Upper Income >Tk. 25000	560 (32%)	460 (27%)	132 (7.5%)	345 (20%)	240 (13.5%)	1737
Total	2723	2266	697	909	713	7308

Source: Field Survey December, 1989.

Table-A17:

Distribution of Trip Rates by Monthly Household Income

TPH INC	2	4	6	8	10	12	14	16-28	Total	Trip Rate
Low Income	33	66	86	96	71	25	15	4	396 (51.1%)	7.74
Middle Income	4	17	23	66	55	37	30	20	252 (32.5%)	9.94
Upper Income	0	3	0	6	17	20	37	44	127 (16.4%)	13.66
Total	37 (4.8%)	86 (11.1%)	109 (15.1%)	168 (21.7%)	143 (18.5%)	82 (10.6%)	82 (10.6%)	68 (8.8%)	775 (100.00)	9.43

Source: Field Survey December, 1989.

Table-A18:

Mode Use Pattern by Sex

Mode / Sex	Bus/ Minibus	Chater Bus	Car/ Jeep	Auto-rickshaw Mishuk	Tempo	Motor Cycle/ Bi-cycle	Rick-shaw	Walk	Mixed Mode	Others	Total
Male	586	177	624	61	272	168	1106	2063	345	38	5439
Female	88	75	263	32	34	17	736	576	42	6	1869
Total	673	252	887	93	306	185	1842	2639	387	44	7308

Source: Field Survey December, 1989.

Table-A19:

Distribution of Male and Female by Education Level

Sex / Education Level	Male	Female	Total
Primary	391 (21.0%)	219 (26.5%)	610 (22.76%)
Secondary	565 (30.48%)	251 (30.39%)	816 (30.45%)
Higher Secondary	329 (17.75%)	186 (22.5%)	515 (19.22%)
Graduation	462 (24.92%)	136 (16.46%)	598 (22.31%)
Illiterate	107 (5.77%)	34 (4.1%)	141 (5.22%)
Total	1854 (69.2%)	826 (30.8%)	2680

Source: Field Survey December, 1989.

Table-A20:

Co-efficient of Correlation of Selected Variables

Variable	TPH	FS	INC	TL	MOT	POT	NVO	TJT	EMP
TPH	1.000 P=. .	0.437 P=0.00	0.600 P=0.00	0.613 P=0.00	0.159 P=.001	0.339 P=0.00	0.411 P=.002	0.560 P=.001	0.261 P=.000
FS	0.437 P=0.00	1.000 P=. .	0.279 P=0.00	0.316 P=0.00	0.131 P=.004	0.237 P=0.00	0.202 P=0.00	0.416 P=.000	0.392 P=.000
INC	0.600 P=0.00	0.279 P=0.00	1.000 P=.	0.577 P=0.00	-0.296 P=0.00	0.093 P=.005	0.458 P=0.00	0.523 P=.000	0.313 P=.002
TL	0.613 P=0.00	0.316 P=0.00	0.577 P=0.00	1.000 P=...	-0.274 P=0.00	0.156 P=0.00	0.408 P=0.00	0.847 P=.002	0.280 P=.004
MOT	0.159 P=.001	0.131 P=.004	-0.296 P=0.00	-0.275 P=0.00	1.000 P=...	0.215 P=0.00	-0.221 P=0.00	0.247 P=.000	0.193 P=.000
POT	0.339 P=0.00	0.237 P=0.00	0.093 P=.005	0.156 P=0.00	0.215 P=0.00	1.000 P=...	0.114 P=.001	0.098 P=.000	0.201 P=.001
NVO	0.411 P=.002	0.202 P=0.00	0.458 P=0.00	0.407 P=0.00	-0.220 P=0.00	0.114 P=.001	1.000 P=. .	0.536 P=.000	0.142 P=.000
TJT	0.560 P=.001	0.416 P=.000	0.523 P=.000	0.847 P=.002	0.248 P=.000	0.098 P=.000	0.536 P=.000	1.000 P=.	-0.273 P=.000
EMP	0.261 P=.000	0.392 P=.000	0.313 P=.002	0.280 P=.004	0.193 P=.000	0.201 P=.001	0.142 P=.000	-0.273 P=.000	1.000 P=...

APPENDIX-B

HOME-BASED TRIP GENERATION MODELLING FOR DHAKA CITY

(Household Survey - as a part of research work for the degree of Master in Urban and Regional Planning)

Department of Urban and Regional Planning,
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DHAKA-1000

Date .....

Name of the head of the household .....
Address: Holding No. ..... Road No..... Area .....

IDENTIFICATION

Record No. :		1
Area Code No. :		2-3
Sample No. :		4-6
Area Class :		7-8

---

1. Size of the family (maximum nine members including servant(s)) [ ] 9

2. Person(s) employed [ ] 10

3. Total household expenditure per-month (Tk. 0 to Tk. 1000 = 1,1001 to 2000 = 2,2001 to 3000 = 3, 3001 to 5000 = 4, 5001 to 10,000 = 5, 10001 to 15,000 = 6, 15001 to 25,000 = 7, 25,000 + = 8, Missing value = 0) [ ] 11

4. Type of the structure that reside in (Pucca = 1, Semi-pucca = 2, All-tin = 3, Kantcha = 4, Missing = 0) [ ] 12

5. Type of the structure that reside in (Pucca = 1, Semi-pucca = 2, All-tin = 3, Kantcha = 4, Missing = 0) [ ] 13

6. Ownership of the residence (Owned = 1, Rented from govt. = 2, Rented from pvt. = 3, Occupied = 4, Missing = 0) [ ] 14

7. Income from House rent if owned (Tk.0. to Tk. 1000 = 1, 1001 to 2000 = 2,2001 to 3000 = 3, 3001 to 5000 = 4, 5000 to 10000 = 5, 10001 to 15000 = 6, 15001 to 25000 = 7, 25000 + = 8, Missing value = 0) [ ] 15

8. Rent of the house if rented

(Tk.0 to 1000 = 1, 1001 to 2000 = 2, 2001 to 3000 = 3, 3001 to 5000 = 4, 5001 to 10000 = 5, 10000 + = 6 Missing = 0 Not applicable = 9)

[ ] 16

9. Net household income per month
(Sources: wages & salaries, agricultural, social & insurance, business/commercial pension etc.) (Tk. 0 to 1000 = 1, 1001 to 2000 = 2, 2001 to 3000 = 3, 3001 to 5000 = 4, 5001 to 10000 = 5, 10001 to 15000 = 6, 15001 to 25000 = 7, 25000 + = 8, Missing = 0)

[ ] 17

10. Number of vehicle(s) owned

[ ] 18

11. Type of vehicle(s)
(Car/Jeep (Pvt.). = 1, Car/Jeep (Govt.) = 2, Auto-rickshaw/Mishuk = 3, Rickshaw = 4, Cycle = 5, Others = 6, Missing = 0, Net applicable = 0)

[ ][ ] 19-20

12. INFORMATION ABOUT TRIPMAKERS:

Member ID / Information	1	2	3	4	5	6	7	8	9	
Sex										21-25
Age										26-30
Education Level										31-35
Occupation										36-40

Sex

Male = 1
Female = 2

Age

0-5 Yrs = 1
6-15 " = 2
16-25 " = 3
26-35 " = 4
36-45 " = 5
46-55 " = 6
55 + - " = 7
Missing

CODING

Educational Level		Occupation			
Primary	= 1	Professionals	= 1	Manufacturing and General	
Secondary	= 2	Admin. + Managerial	= 2	Worker	= 8
Higher Secondary	= 3	Student	= 3	Craftman & Other	= 9
Graduation	= 4	Housewife	= 4	Missing Value	= 0
Illiterate	= 5	Clerical + Related	= 5		
Missing Value	= 0	Self Employed	= 6		
		Sales + Services	= 7		

13 TRIP INFORMATION - MADE ON YESTERDAY :

Day of the trip
Saturday = 1, Sunday = 2, Monday = 3,
Tuesday = 4, Wednesday = 5, Thursday = 6,
Friday = 7, Missing Value = 0. ☐ 41

Member identification no. ☐ 42

Location of the workplace or school .....

About trip Sl. No.	Trip type	Time of the day	Total journey time	Trip length	Mode of travel	Reason for using this modes	Cost required	Purpose of the trip	
1									43-50
2									51-58
3									59-66
4									67-74
5									2-9
6									10-17

Member identification no.

Location of the workplace or school 18

About trip Sl. No.	Trip type	Time of the day	Total journey time	Trip length	Mode of travel	Reason for using this modes	Cost required	Purpose of the trip	
1									19-26
2									27-35
3									36-43
4									44-51
5									52-59
6									60-67

Member identification no.

Location of the workplace or school 68

About trip Sl. No.	Trip type	Time of the day	Total journey time	Trip length	Mode of travel	Reason for using this modes	Cost required	Purpose of the trip	
1									69-76
2									2-9
3									10-17
4									18-25
5									26-34
6									35-42

Member identification no.

Location of the workplace or school ..... [ ] 43

About trip Sl. No.	Trip type	Time of the day	Total journey time	Trip length	Mode of travel	Reason for using this modes	Cost required	Purpose of the trip	
1									44-51
2									52-59
3									60-67
4									68-75
5									2-9
6									10-17

Member identification no.

Location of the workplace or school ..... [ ] 18

About trip Sl. No.	Trip type	Time of the day	Total journey time	Trip length	Mode of travel	Reason for using this modes	Cost required	Purpose of the trip	
1									19-26
2									27-35
3									36-43
4									44-51
5									52-59
6									60-67

Trip type

Home-based = 1
Non-home based = 2
Missing = 0

Time of the day (Time of start)

5.00 A.M. - 9.00 A.M. = 1
0.91 A.M. - 12.00 P.M. = 2
12.01 P.M. - 3.00 P.M. = 3
3.01 P.M. - 5.00 P.M. = 4
5.01 P.M. - 8.00 P.M. = 5
8.01 P.M. - 12.00 P.M. = 6
Missing value = 0

Mode of travel

Bus/Minibus = 1
Carter bus = 2
Car/Jeep = 3
Auto-rickshaw
Mishuk = 4
Tempo = 5
Cycle = 6
Rickshaw = 7
Walk = 8
Bus + Tempo = 9
Bus + Rickshaw = 10
Tempo + Rickshaw = 11
Others = 12
Missing Value = 0

Reasons

Safe = 1
Convenience/ Comfortable = 2
Inexpensive = 3
Easily available = 4
Having no bus route = 5
Others = 6
Not applicable = 9
Missing = 0

Journey time (min)

0 - 15 = 1
16 - 30 = 2
31 - 45 = 3
46 - 60 = 4
60 = 5
Missing = 0

Cost required

Tk. 0 -Tk. 1.00 = 1
Tk. 1.01 -Tk. 3.00 = 2
Tk. 3.01 -Tk. 5.00 = 3
Tk. 5.01 -Tk. 10.00 = 4
Tk. 10.00 + = 5
Not applicable = 9
Missing value = 0

Trip length (mile)

0 - 1.00 = 1
1.01 - 2.00 = 2
2.01 - 3.00 = 3
3.01 - 5.00 = 4
5.00 + = 5
Missing = 0

Purpose

Work trip = 1
School trip = 2
Shopping trip = 3
Socio-Recreational = 4
Others = 5
Missing = 0

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